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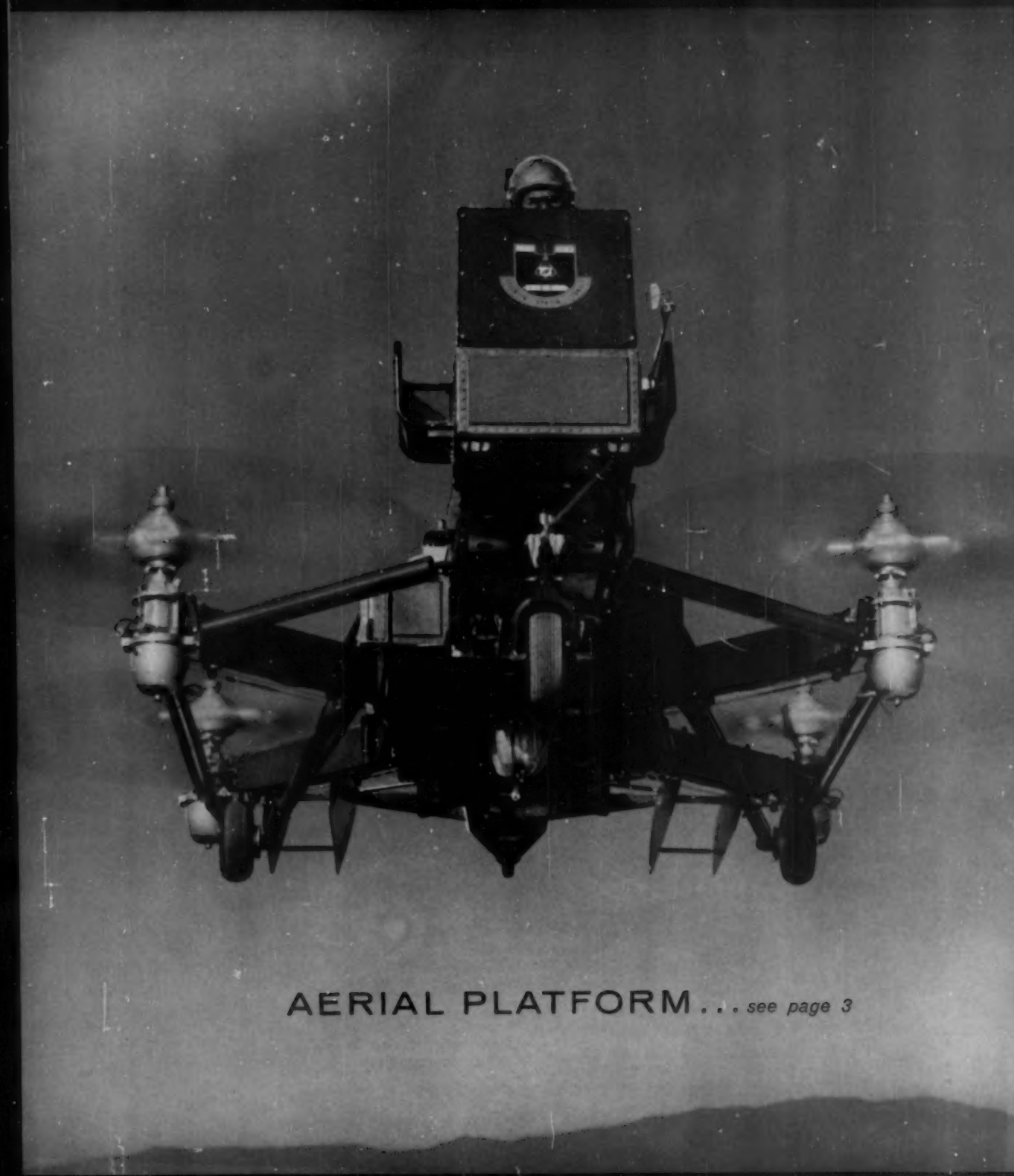
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · FEBRUARY 29, 1960



AERIAL PLATFORM . . . *see page 3*

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Whatever the Oliver OC-12 is bulling through . . . liquid ooze, dirt, or gale-blown desert sand . . . nothing can get into the track wheel bearings. Oliver engineers saw to that. They specified C/R Type VS End Face Seals with metal-to-metal contact to protect those bearings. The metal faces in these seals are lapped to within 3 lightbands of being optically flat. Nothing can get in . . . and the fluid lubricant inside can't get out . . . no matter how rugged the duty. Oil seal dependability like this means fewer lube checks, fewer lube changes . . . less downtime. And *that* means big savings for Oliver users.

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

February 29, 1960 Vol. 31, No. 9

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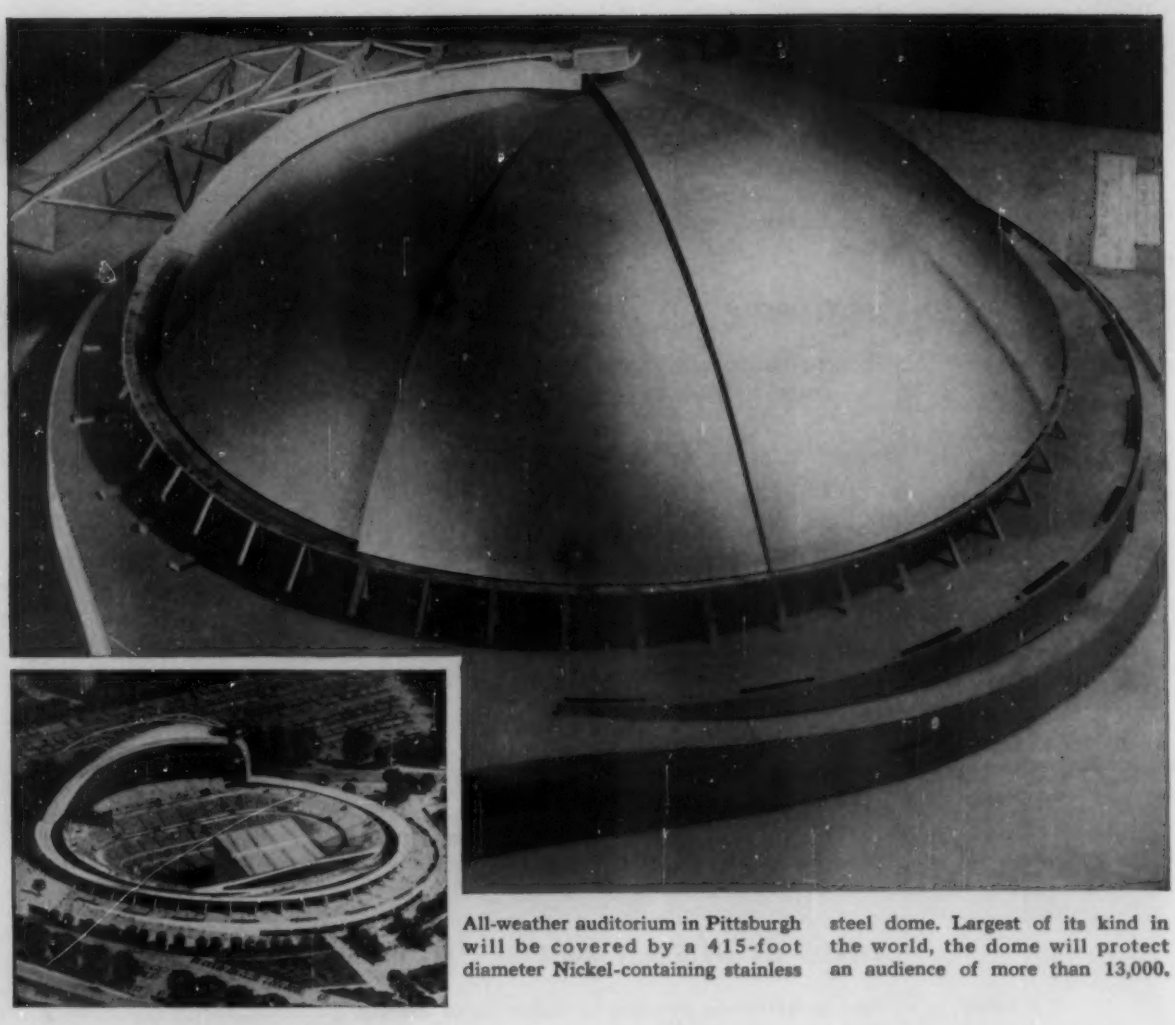

All-weather auditorium in Pittsburgh will be covered by a 415-foot diameter Nickel-containing stainless steel dome. Largest of its kind in the world, the dome will protect an audience of more than 13,000.

"Push-button umbrella roof" of stainless steel gives Pittsburgh a new all-weather auditorium

Watching a play or listening to music under the stars heightens the enjoyment. That is, until a passing shower comes along to wash out the fun. But now comes a new idea in auditoriums. In this one, an umbrella roof of Nickel-containing stainless steel will close at the first drops of rain—and on with the show.

It's a simple concept, but a daring one. Eight huge sections nest together when the dome is open. Push a button, and six of these sections glide quietly together around an outside track.

They looked into all sorts of sheathing materials in designing the dome before choosing stainless – a Nickel-containing stainless steel.

For stainless with Nickel in it is one of the most weatherproof metals there is. It is corrosion-resisting all the way through – in salt air as well as industrial atmospheres. What's more, it's virtually self-cleaning – rainfall alone keeps this metal clean.

No wonder you see Nickel-containing stainless wherever strength, long life and handsome appearance are called for! Not only in buildings – inside and out – but everywhere you look.

Suggest something to you? Can stainless help you solve a problem involving corrosion, stress, appearance, temperature extremes? The way to find out is to write us. We'll see if Nickel-containing stainless steel – or some other nickel alloy – may be just what you're looking for.

THE INTERNATIONAL NICKEL COMPANY, INC.

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INTERESTING TO NOTE

When Langley Failed to Fly

Government expenditure for aeronautical research has made a complete turnabout since federal scientists first started experimenting with heavier-than-air craft. In the past fiscal year, the government spent millions of dollars developing new concepts in aviation as well as improving the old. However, in 1904, Congress inserted a clause in the budget forbidding the use of governmental funds for "flying-machines." This clause was a direct result of Samuel Langley's failure to build and successfully fly an airplane.

As secretary of the Smithsonian Institution, Langley had received a grant of $50,000 from the War Department and $20,000 from the Smithsonian to develop a "man-carrying aerodrome." Together with his assistant, Charles M. Manley, he first experimented with steam engines, then gasoline engines, finally developing the world's first radial engine. This he attached to a 750-lb aircraft—to be catapulted from a boat on the Potomac (see photo, right). On Oct 7, 1903, Manley donned a life preserver and climbed into the craft. Unfortunately, part of the catapult failed to function and the "aerodrome" went plunk into the Potomac. A second attempt was made a month later, but again the catapult failed—this time destroying the experimental craft.

Newspaper reporters, who were banned from observing the experiment, let out a howl of protest when Langley failed to fly. Said the New York *Times*: "We hope that Professor Langley will not put his substantial greatness as a scientist in further peril by continuing to waste his time, and the money involved, in further airship experiments. Life is short, and he is capable of services to humanity incomparably greater than can be expected to result from trying to fly." Fortunately, the Wright brothers must not have read this piece in the *Times*. Nine days after the faulty catapult wrecked Langley's plane, the Wright brothers made the world's first powered flight at Kitty Hawk, NC.

There have been a lot of strangely shaped heavier-than-air craft since Kitty Hawk—helicopters looking like dragon flies; flying wings looking like bats. And still in the development stage are the flying platforms. One of the more interesting ones is shown on our cover—the VZ-7AP aerial platform, a test vehicle built by Curtiss-Wright (Santa Barbara Div) at Goleta, Calif for the Army Transport Corps. It has four unshrouded, variable-pitch propellers driven by a single 420-hp Turbomeca Artouste through a 4-way takeoff.

Smithsonian Institution

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Individual pitch adjustments for each propeller control altitude or level. Actually, it's a kind of flying gearbox, held together by the propeller-shaft tubes, which are plainly visible in this shot taken especially for us.

Animals on Mars?

Space flight has intrigued man since the first caveman watched with envy as the first pterodactyl soared overhead. Through the ages man has dreamed of getting airborne but not until the 18th century did he temporarily free himself, by soaring in a balloon, from the hold of gravity. Now, we're gaining the ability to leave the earth's gravitational field altogether and begin manned space exploration. What must the design engineer know about space to design the equipment to be used by the Columbus of tomorrow? In an exclusive interview (p 24) Dr Harold Urey tells us the problems faced by those concerned with designing for the moon.

But what about the planets? Is there some sort of life anywhere out there in space? Dr. I M Levitt of the Fels Planetarium, Philadelphia, believes there is. According to Dr Levitt, a small furry animal may greet the first spaceship to land on Mars. Such animals wouldn't have lungs, because Mars has so little atmosphere. They wouldn't drink water either, but would get whatever liquid they need–plus small amounts of oxygen–from plants.

Beans to Bearings

Whether you're sealing a bearing (p 54) or a can of beans, the purpose remains the same—protect the object from moisture, dust and, if it's food, from decay. The discovery by a French pastry cook, Nicolas Appert, that the combination of heat and the exclusion of air could preserve foods led to new culinary experiences for thousands of people. For the first time, people living inland could get a taste of seafood and those on the coast could eat freshly canned fruits.

Celebrating its 150th birthday this year, the canning industry has progressed from a painstaking operation by hand to a multibillion-dollar business. Every day, Americans open about 100 million containers of canned food. About 1200 kinds of food now come in cans, from A to Y (for "youngberries"). So far no one has canned the Italian dessert called "zabaglione" to complete the alphabet, but that, too, may come. By 1845, machines were introduced for husking corn and for shelling peas. The Civil War, with its heavy demand by the armies for preserved foods, increased the production by 60%, and the invention of the pressure kettle in 1874 further added to the growth of the industry. The new apparatus raised and controlled cooking temperatures, thus cutting down cooking time and making it possible to process food scientifically.

Now, the American canning industry processes more than 22 billion pounds of food a year. About 2500 canneries operate in 49 of the 50 states (Nevada is the exception) and the US Department of Agriculture estimates that the statistical creature called "the average American" eats more than 136 pounds of canned food a year. This brings about an interesting problem. Isn't there a way we can use all those empty cans?

—Benedict H Leerburger Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **When You Need a Vibrator**

Vibrations in equipment aren't always undesirable. Article will describe the four main types of vibrators.

. . . **Product Pricing**

You can't separate design and price. Here, an expert will tell what you should know about marketing a product.

. . . **High-impact Phenolics for Shock Applications**

Adding fiberglass reinforcement can make conventional phenolic resins a strong competitor to metals where shock loads are a problem.

. . . **Selecting Compressor Types**

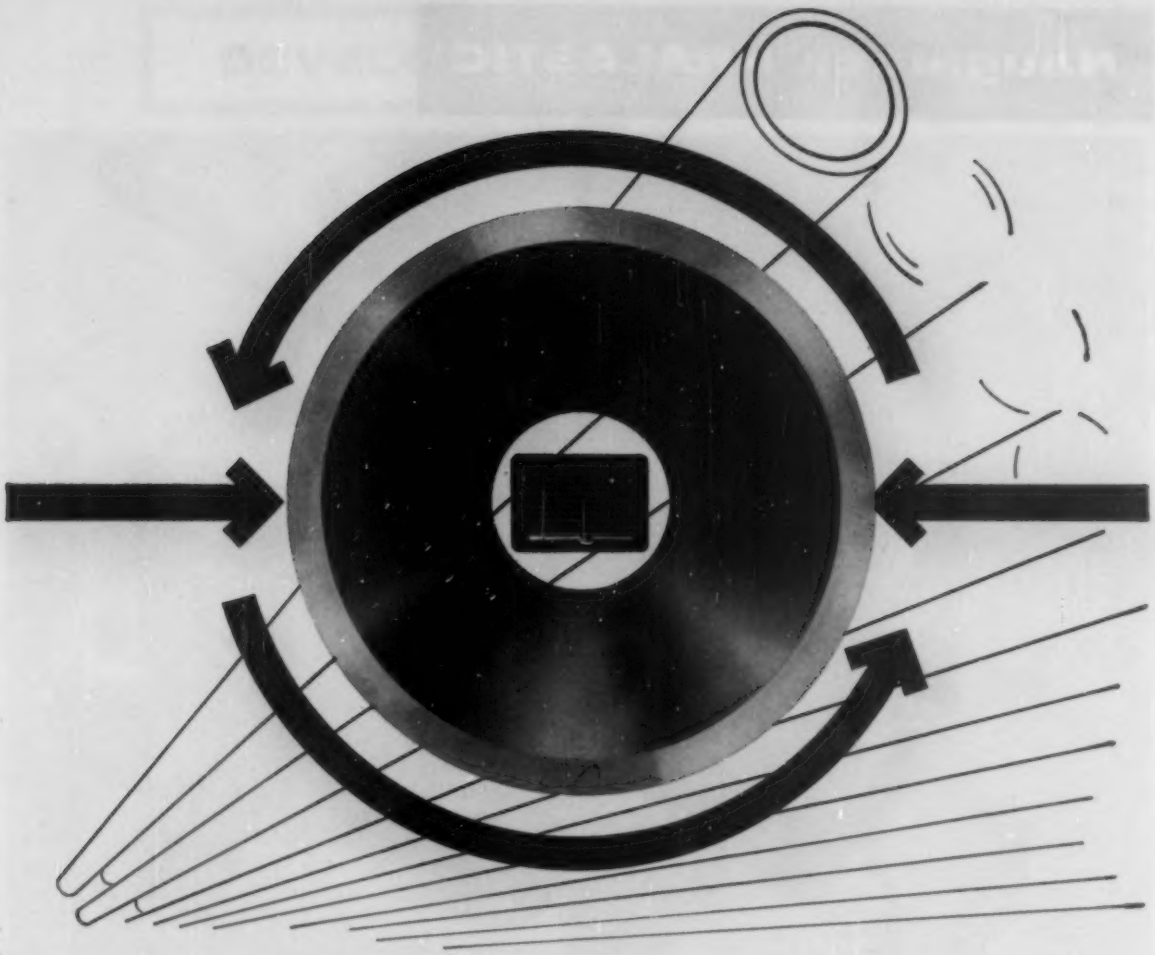
How to use the "adiabatic head" concept. Step-by-step method, including all needed reference data.

. . . **Recruiting Graduating Engineers**

A guide to what they're looking for; and what they're not.

. . . **9 More Ways to Change Straight-line Direction**

These devices use gears, cams, pistons and solenoids.



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You get substantial savings with this sounder, more uniform tubing

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You can save on installation time. Every tube fits right and rolls in easily because it's uniform in size and tolerances. It bends easily *with the weld in any position.*

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B&W LECTROSONIC Tubing is available now either direct or through distributors.

Write today for B&W Bulletin TB-431 for full information—or call your nearest B&W District Sales Office. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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The very properties that have made KRALASTIC rubber-resin so outstandingly successful in pipe... for oil, gas, water, chemicals and underground electrical conduit... offer a host of interesting possibilities for other extrusion products of all kinds. Consider:

KRALASTIC holders for 45 r.p.m. record player spindles have just the springiness required to hold the spindle in place, yet have a tough flexibility that is non-marring to the spindle finish.

Tuning shaft extensions of KRALASTIC provide the torque resistance required, yet are tough enough to prevent accidental breakage. And KRALASTIC's good dimensional stability allows press-fit couplings to both the tuning knob and the tuner itself.

Radio chassis glides of KRALASTIC are not only effective insulators, but are also self-lubricating to ease installation and removal of the chassis from the cabinet.

Investigate the properties of KRALASTIC in relation to your own extrusion products. They could spell product improvement. For full information, write the address below.

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DEVELOPMENTS TO WATCH...

New probe reveals flow conditions

A novel method for detecting conditions inside fluidized bed systems has been devised by United Kingdom Atomic Energy Authority engineers.

As they point out, conventional electrostatic and pneumatic probes for detecting clogging and turbulence in gas-borne streams of moving particles are limited in application and frequently not too reliable.

The new instrument is electrothermal. It uses an electrically heated probe, maintained at a fixed temperature above that of the bed itself. By measuring the amount of current required to hold the probe at the specified temperature, an indication of rate of flow and perturbations in the bed itself may be obtained.

The device has been patented and is to be licensed for commercial production.

New polyethylene flows faster

Thinner, more effective coatings for metals, and greater ease in molding large and irregularly shaped parts are among the advantages claimed by US Industrial Chemicals for its new fine-particle polyethylene powders, going into semicommercial production next month.

Because the powders are extremely fine, USI says, they lend themselves to fluidized-bed application and to molding processes that resemble slush coating.

Initially, two types will be supplied: One, made by a solution process, has round particles, 75 microns or less in dia (200 mesh). The other, produced by mechanical methods, has coarser less-regular particles, ranging in size up to 300 microns (50 mesh). Both types will be available in either low or medium density (0.916 and 0.924), with other sizes and types to be added later. Developmental prices are 40¢/lb for the coarser material; 65¢/lb for the finer.

Semiconductor regulates current

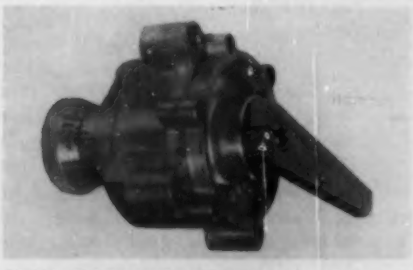
To control battery and electrical-system operation in motor vehicles, a German manufacturer has designed a semiconductor current-regulator that's said to be simpler, smaller, and more reliable than conventional coil units. Heart of the system is an insulated germanium diode which controls the current flow, and offers, its designer claims, two special advantages:

Its response is keyed to the ambient temperature so that, under starting conditions, battery charging begins immediately, and at the maximum rate (a big advantage for short-run driving).

The response curve of the device is such that it introduces a certain 'inertia" to the switching process, making it possible to operate the dynamo (generator) without risk of switching transients.

Robert Bosch GmbH, Stuttgart, W Germany, is introducing it commercially.

Adjustable-rate dashpot designed in Britain



NEW DASHPOT FEATURES calibrated knob that makes it possible to obtain any desired damping rate.

For applications where automotive-type shock absorbers can't do the job, Kinetrol Ltd, Surrey, England has designed an adjustable-rate silicone-fluid dashpot "of instrument quality."

The shaft is on ball races, and a positive seal is provided by a flexible rubber sleeve bonded to both cover and shaft. Rate ranges are 2 to 2000 lb-in./rad/sec. Use of die-cast components, Kinetrol says, makes possible "a large cut in the cost." A differential-rate model, which gives a large resistance in one direction only, has also been designed. Cost of the adjustable-rate model is about $27 (US equivalent); the differential rate unit is about $20. The fixed rate model, previously available is $16.

Caution signals on new electronic devices

Thin-film and "molecular" electronic circuits offer great promise for miniaturization, but they're not nearly as close to full commercialization as might be thought.

The idea of combining, on a single tiny wafer, a whole circuitful of resistors, capacitors, diodes and transistors is certainly an attractive one. Even more enticing is the idea of creating, within a single semiconductor bar or film, the functions normally carried by several individual components. Such an arrangement would eliminate assembly problems, and make it easy to pack a million or more elements in a space hardly the size of a lump of sugar (*PE*—Apr 20 '59, p 9).

But the problems in designing and producing such "simplified" circuits are a lot more numerous than they were expected to be.

In the multi-component semiconductor circuit, for instance, each element added to the wafer reduces the over-all yield and reliability—to a point where, in many cases, the yield of satisfactory finished products is well below 10%.

With the single-film ("molecular") circuits, the problems are even more acute. There is as yet no semiconductor material that, even with appropriate "doping," will serve equally well as a capacitor, resistor, and diode.

New route to refractory alloys promises lower costs

A "one-step" system that's claimed to produce high-purity molybdenum-, titanium-, and vanadium-containing alloys (titanium-bearing aluminum master alloys, for instance) directly from oxide mixtures has been developed by Alscope Explorations Ltd. Use of "cheap oxides," and related processes for recovery of byproducts, is claimed to make the system "exceedingly economical."

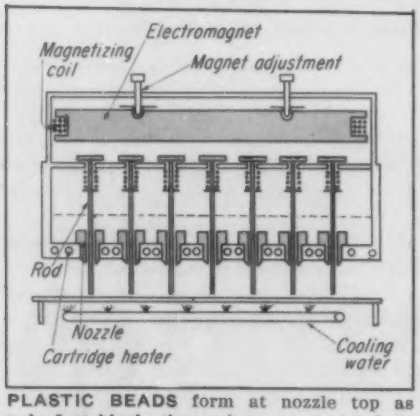
The oxides, a reducing metal, a nonreacting metal which is to form the larger component of the alloy, and slag-dissolving salt are melted together in an induction furnace, maintained at 2000 to 2500 F, and the alloy is withdrawn on a continuous basis.

Phosphorus worth its weight in gold

The "purest grade of elemental phosphorus that has been produced commercially" is being made available by American Agricultural Chemical Co. It's said to be better than 99.9999% pure, is priced at about $100 an ounce, packed in quartz ampoules.

Besides its use in such materials as gallium phosphide, the new high-temperature semiconductor, the company expects it to pave the way for new and improved electroluminescent phosphors. It might well prove useful in metallurgical studies too.

Germans design machine that spits out plastic beads



PLASTIC BEADS form at nozzle top as rods first block, then release, material flowing through pipe and nozzle.

A novel rod-and-nozzle system has been devised by W German engineers to produce spheres of plastics and other materials (soaps, waxes) which can be dissolved or melted. It uses magnetically controlled, rapidly moving metal rods inside a series of nozzles to first shut off and then accelerate material flow. This creates a series of pulses, each of which results in a spewing-out of drops of material that can be rapidly solidified to form the desired beads.

As the diagram shows, the rods move up and down inside the pipe and nozzle through which the material feeds from the melting tank to the cooling bath.

An electromagnet, intermittently energized, pulls the rods up by magnetizing the soft-iron heads attached to them. Then, as the current is interrupted, spring action pulls the rods down, the process being repeated rapidly and continuously.

The device has been patented and assigned to Continental Gummi-Werke AG, Hannover. —ARG

WHAT'S HAPPENING IN RESEARCH . . .

Non-embrittling baths reported by Navy

The Navy's long-term attack on hydrogen embrittlement is beginning to pay off.

Recent research at Naval Research Lab has uncovered two plating baths, one aqueous and one alcohol-based, which it terms definitely non-embrittling.

Both baths contain triethanolamine. The aqueous bath can be used at room temperature, with a current density of 19.2 amp/sq ft. The alcohol-based bath requires refrigeration—to 32 F; but NRL says this limitation may be removed by more careful adjustment of bath composition.

Other recent NRL findings:

- Baking (at 350 F for 24 hr) can relieve embrittlement resulting from chromium plating. But baking cannot be expected "to completely disembrittle high-strength steels plated with zinc or cadmium from conventional baths."
- Variation in embrittlement susceptibility between certain heats of steel seems more a reflection of variation in susceptibility to brittle fracture than to hydrogen itself.
- Over-all fracture susceptibility does vary from one type of steel to another, with hardenable steels (except AISI 1020) harder than Rockwell C-30 being especially susceptible (*PE—Jan 4, p 8*).

What it means in solid state

What's the band theory of solids? Bulk modulus? Electrostriction? How can dielectric amplifier, dielectric breakdown, dielectric constant, and dielectric loss be explained in simple terms? You'll find the answers in an excellent *Glossary of Terms Used in Solid-state Physics*, that the American Institute of Physics prepared for a special science writers' symposium. Now, AIP has printed it in a 26-page booklet and has offered to make it available to PE readers—one to a customer, though; supply is limited. Address requests to Eugene Kone, AIP, 335 E 45th St., New York 17.

This tracing converter simplifies data comparison

Linear data with diverse X and Y scales can be compared directly with the aid of the converter pictured here, developed at Naval Ordnance Laboratory. It's superior to the ordinary pantograph or projector, says R. S. Price of NOL, in that the X and Y axes can be varied to permit free choice of scale in both directions.

The converter can handle photographs, oscilloscope records, line drawings, and even direct optical projections; and, says Price, "since the outputs of the converter are dc signals, they can probably also be fed through a digitalizer into a digital computer or directly into an analog."

The device consists of a Y carriage, sliding on an axis rod which, in turn, is mounted on the X carriage. The axis rod of the latter is attached to the table by brackets. Movement of the Y carriage is linked to a 10-turn potentiometer by means of a wire, sheave, and drum system. The X carriage is similarly linked to a 5-turn potentiometer. Two bridge circuits, also equipped with potentiometers to zero the output at any point on the tracing area, are powered by individual mercury cells.

In the model shown, the tracing area is 8 by 16 in., and the amplification 1 to 5 times (about a 10-to-1 reduction when the input is fed into the X-Y plotter). Gain limits are controlled by the spacing of the turns of wire in the potentiometers, by the resolution of the X-Y plotter, and by the guidance of the operator.

NOL CONVERTER operates much like standard pantograph, but permits independent magnification or reduction of data for each axis. Here, pressure-time graph is being converted. X-Y plotter is shown in foreground.

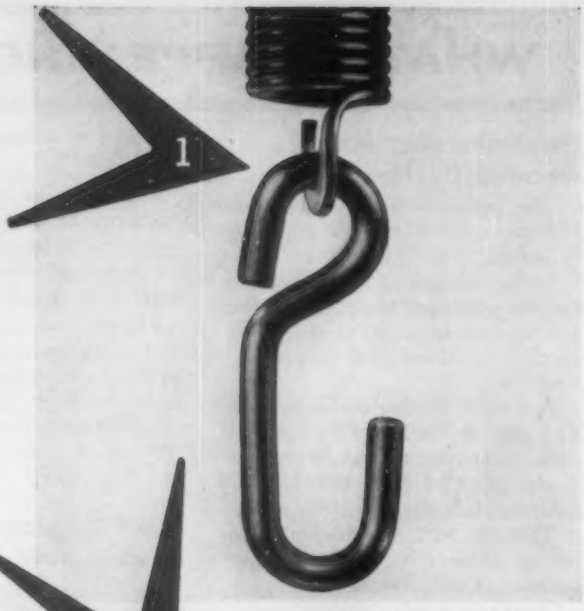
briefs . . .

World screw-thread standards are compiled in a handy 41-page printed manual compiled by W H A Robertson & Co Ltd, Lynton Works, Bedford, England. More than 100 screw-thread forms are illustrated, and more than 2000 standards listed. Prepared primarily as a service to its customers by Robertson, this 41-page manual is available at the "contributory price" of 10 shillings (about $1.40).

Nonmetals can be converted into metals by ultrahigh pressures, Lawrence Radiation Laboratory reports; but the metallic state is lost when the pressure is released. Using pressures of 2 to 3 million psi, Lawrence researchers have converted both phosphorus and silver oxide to the metallic state; believe that slightly higher pressures can convert iodine as well. At 2 to 3 million psi, they say, both phosphorus and silver oxide, normally electrical insulators, show a distinct electrical conductivity. It's not high (about 1/50 that of ordinary copper), but it does represent an increase, in the conductivity of phosphorus of "about a billion-fold."

New sodium-potassium alloys being made available by MSA Research Corp, Callery, Penna show melting points as low as 10 F; with boiling points in the 1400-1500 F range. They show good electrical and thermal conductivity as well (though resistivity is about twice that of the pure metals); and, says MSA, they show promise as scavengers for removing impurities from such organic fluids as benzene and the light oils, as well as for heat transfer applications. Four-gram samples (up to 3) are available without charge; additional supplies at $1 each. In quantity, prices range from about $2 to $4/lb.

Why it pays to look at the end in the beginning



1. In this pick-arm spring for a textile machine, natural frequency vibration plus rigid end restraint caused early failure. By redesigning spring and adding swivel hook to end assembly, failure was avoided and cost reduced as well.

2. Fatigue failure caused by bending stresses occurs where end hooks join working coils. In this method of reducing the combined stress, two coils at each end are wound with a reduced diameter.

3. Another method for reducing stress concentration where end hooks join coils is to thread a flat stamping into end coils.

Here are a few examples of why it pays to call on the springmaker early in your design problems. End-hook failure of extension springs is a common occurrence that experience can help avoid. Check your specifications for performance and production economy by consulting an A.S.C. spring engineer. Write for bulletin "How to Solve Your Spring Design Problems."

5903

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Easy to install! Easy to service! Hard to wear out!

LINK-BELT "RC" COUPLINGS

Here's a flexible coupling that's ✓simple ✓dependable ✓inexpensive

SIMPLE! Link-Belt "RC" couplings consist of two sprocket halves joined flexibly with a piece of roller chain. The chain is specially constructed for flexible coupling service—it is of single width construction, but has extra overall width and *divided rollers* which provide independent contact with each sprocket tooth . . . equalize load . . . compensate for shaft misalignment. Especially important, "RC" couplings are easy to install . . . easy to take apart and put together.

DEPENDABLE! Chain and sprocket halves are made of quality steel. In addition, sprocket teeth and chain parts are hardened. The resulting *extra* strength and wearability pays off in long, dependable service.

INEXPENSIVE! Extremely simple design holds down the cost of "RC" couplings.

HARDENED WEARING SURFACES of both chain and sprocket add extra wear-life to "RC" couplings.

CHOICE OF HOUSINGS

— for retention of lubricant and protection of the coupling. Style R — spun metal, vertical split. Style P — molded plastic, horizontal split.

FULL DETAILS are contained in Book 2363. For your copy, call your nearest Link-Belt office, listed under COUPLINGS in the yellow pages of your phone book.

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LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,158-A

FROM WASHINGTON . . .

Ultramodern construction methods used on supersonic bomber

The Air Force's controversial B-70 bomber is to demonstrate some radical departures from conventional building methods. **Nearly half of the airframe of the Mach 3 craft being built by North American Aviation Inc will be a brazed honeycomb sandwich of high-strength stainless steel.** Need to go to this type of construction is for insulation purposes—to withstand the 500-F temperatures to which the plane will be subjected. Fuselage of the 156-ft-long aircraft will be honeycomb from about the midpoint aft.

Titanium is used extensively in the forward part. Nose of the plane, for example, will be made of this light metal. The B-70 will have its best performance at 2000 mph, with a 600-mi range. It can throttle back to 0.8 Mach for refueling.

FCC sets stereo-equipment standards hearing for March 15

A speed-up on equipment standards for FM stereo broadcasting (multiplex), so manufacturers can begin making receivers, has been decided by the Federal Communications Commission. **It decided to go ahead first with FM stereo, instead of waiting for a study of AM and TV as well.** Hearings on proposed standards begin March 15. The move will delay AM and TV stereo broadcasting.

The Electronic Industries Association had set up a committee to study all three types together, but has disbanded the group. RCA and CBS felt they could not participate without inviting antitrust action unless the FCC agreed to sponsor the group officially. But FCC decided to move ahead with FM stereo—because it is further along than the other two types.

A version of stereo broadcasting already exists—programs beamed on AM and FM simultaneously, with the listener using two different receivers. The proposed innovation would transmit two signals on FM, with new-type receivers designed to pick up both signals on the same set.

Solid-propellant rocket engine to be studied

The Air Force will contract for a new solid-propellant superbooster rocket engine soon. **Six companies have already submitted proposals on the project, with an award expected in the next few weeks.** Thrust range for the vehicle is defined by the Air Force as "between 300,000 and 1 million lb."

The technical approach for building the rocket motor will count more than initial thrust yield in contractor selection. One method proposed by some companies is to assemble the solid rocket on a building-block concept.

Sections of the rocket could be shipped to launch site and coupled together. This, they claim, would cut costs and give the vehicle more adaptability than any existing rocket engine. For example, just enough sections would be coupled together to produce the desired thrust for the job.

The Air Force won't openly label the program a superbooster project. Instead it's called a plan to build a "high-specific-impulse, large-grain, solid-propellant rocket engine." And the President last October specifically made the National Aeronautics and Space Administration the agency responsible for developing superboosters—in the million-lb thrust class.

The Air Force, however, is privately known to be bucking to get its own high-thrust engines for space projects. Current guessing is that Air Force will contract for something less than one-million-lb thrust, but with the capability to be expended into this range. That way, it would escape White House criticism.

Why worry about fabricating laminated plastics? That's our job.

There is not much point to fabricating laminated plastics in your own shop. And there are good reasons why. One is the material itself.

Synthane laminates are available in sheets, rods, and tubes, and in over 33 standard grades. Choice of form and grade for your part is important. For example, a part which is basically tubular may have to be cut from a sheet rather than a tube. Or the material itself may have to be modified in order to meet your requirements.

When you do your own machining, responsibility rests finally with you. The possibility of errors in dimensions, machining and tolerances, and of waste and delay suggest that you buy your laminated plastics from us and let us do the fabricating for you. Call any of our representatives—in principal cities—for a quotation or get in touch directly with Synthane Corp., 4 River Road, Oaks, Pa.

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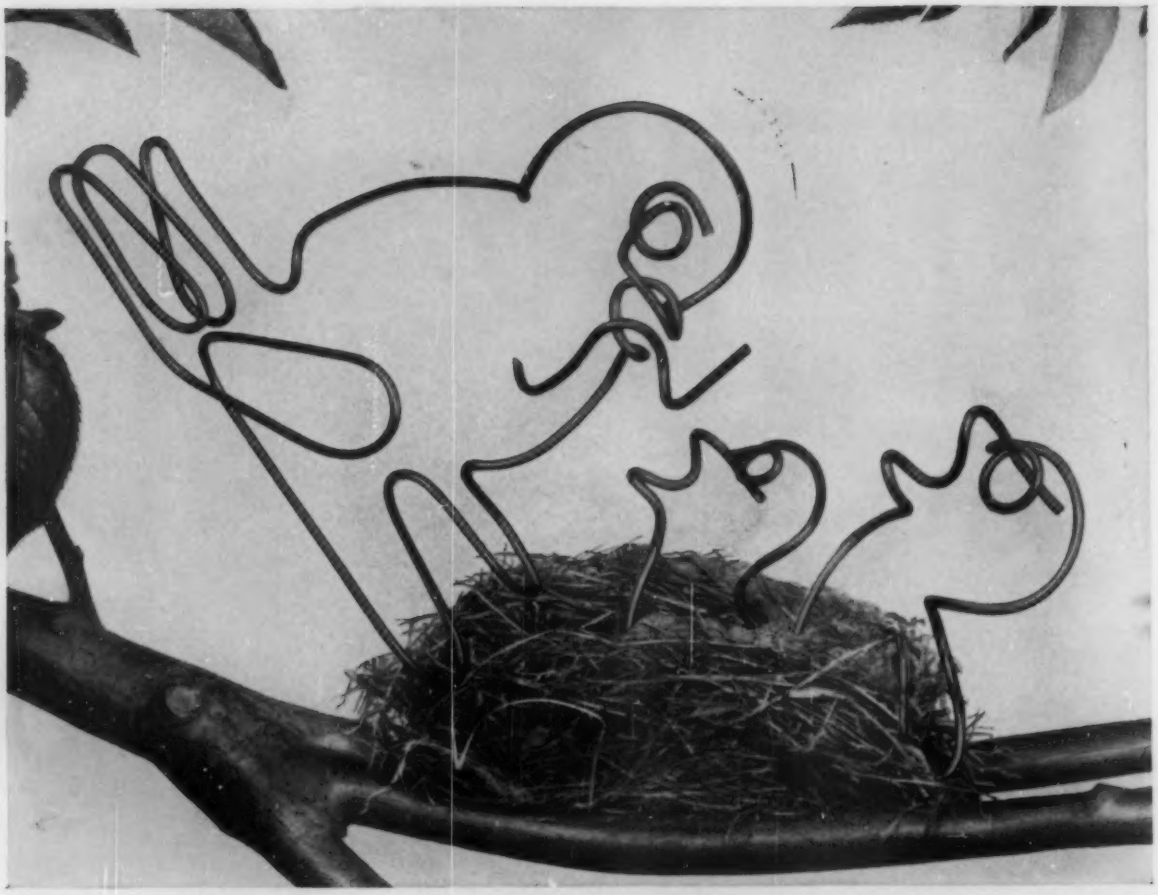


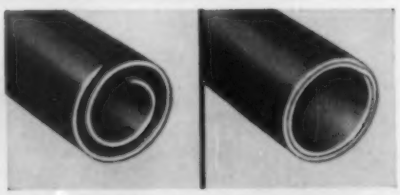
Bundy can mass-fabricate practically anything

. . . with Bundyweld® — double-walled steel tubing that is adaptable to a whole host of applications.

WHATEVER your tubing problems . . . whatever the stage of development of your product, the Bundy man awaits your call. That's because tubing problems are Bundy's business, and Bundy engineers — with years of tubing experience — can often come up with a design angle that'll save you time and money.

But the Bundy service doesn't end there! Specially designed Bundy machines take over the mass-fabrication of these parts in unlimited quantity. And to meet rigid specifications, we use Bundyweld — the original double-walled steel tubing — the safety standard in small diameter tubing. Thinner-walled Bundyweld is stronger and gives you higher bursting and fatigue strengths. Covered by Government Spec. MIL-T-3520, Type III.

Why not bring your tubing troubles to Bundy and take advantage of expert engineering and design, mass-fabrication economies, and Bundyweld tubing? See Sweet's Product Design File 1e/Bu . . . or write directly for full information! Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld is the original tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ⅝" O.D.

There's no substitute for the original Bundyweld Tubing.

BUNDY® TUBING COMPANY

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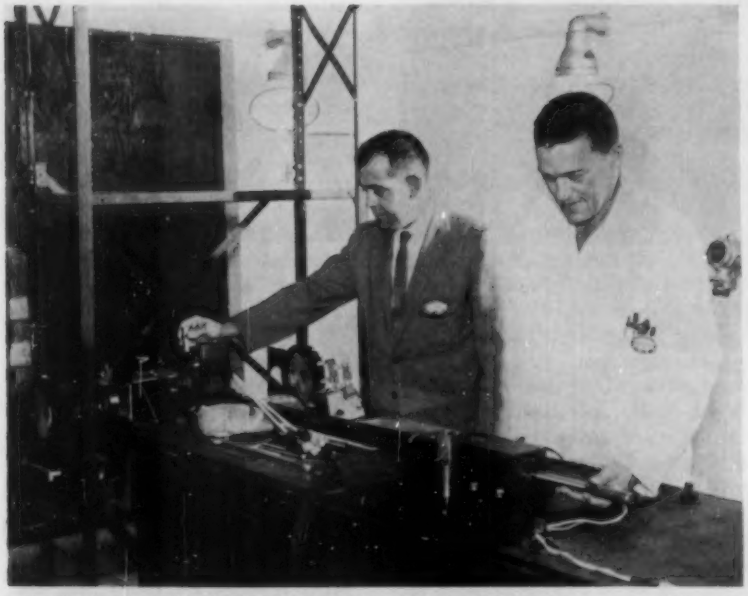
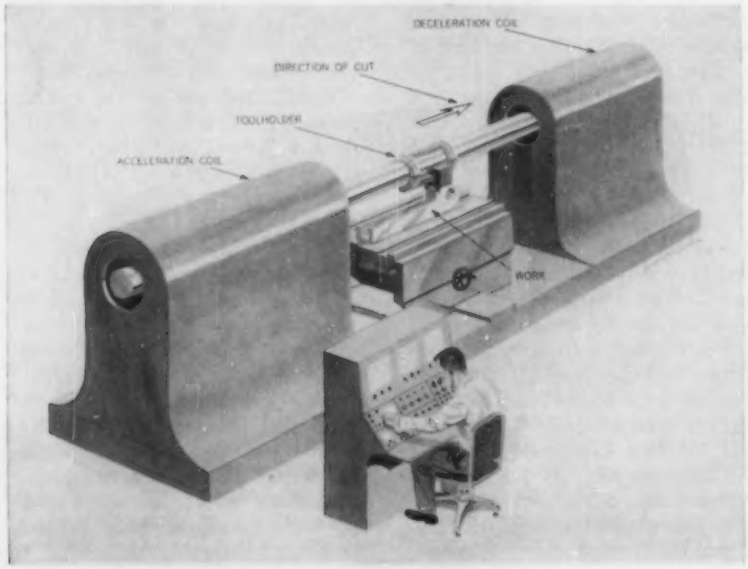
WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY



FIRING THE PROJECTILE-SHAPED TEST SPECIMENS past a toolbit near the muzzle of this 20-mm gun gave Lockheed cutting speeds to 360,000 sfm, a thousand times normal! Tests indicate that . . .

Ultrahigh Machining Speeds May Revolutionize Industry

WILL THE FUTURE SHAPER LOOK LIKE THIS? Design here replaces gun with fast-action solenoid that gives ultrahigh speeds to toolholder.



NEW YORK—Findings that may forecast radical changes both in design of machine tools and in machining methods have just been reported by Lockheed Aircraft as a result of Phase I of a study for the US Air Force Mfg Methods Division. Detailed results are in *American Machinist/Metalworking Manufacturing* for Feb. 22, p 111-126. Tests were run at cutting speeds of 15,000 to 250,000 surface feet per minute, with a few up to 360,000 sfm. Best tool life appeared to be in the range around 120,000 sfm on 4340 and on Ti, Al and stainless alloys.

This represents a radical change from conventional machining speeds of 300 to 1000 sfm on familiar materials, grinding at 5000-6000 sfm, as little as 100 sfm on the hard and tough alloys tested. A few of the lower-speed tests were made by clamping bars on the track and carrying tools past them on a rocket sled at Edwards Air Force Base, the rest by firing test specimens as 20-mm shells past toolbits at the end of a gun barrel.

Tests are thus far inconclusive, but they do provide some interesting data. Horsepower requirements are extremely high for a fraction of a second because of the velocities attained, not because of cutting forces. On annealed or heat-treated 4340, peak power (including impact) is 2450 hp at 30,000 sfm, 12,000 hp at 150,000 sfm. Tool flanks, however, remain at temperatures of 80 to 140 F, as compared with 600 F at the conventional speed of 250 sfm. Heat generated at the tool apparently does not increase in proportion to velocity.

Peak horizontal cutting forces are only 30 to 70% above those at conventional speeds; vertical forces increase substantially to a peak, then drop off as speed is raised. Tool wear drops considerably when cutting speed rises from 30,000 to 120,000 sfm, best tool life being at the higher speed. This is the reverse of the situation at conventional speeds, in which tool wear rises with speed.

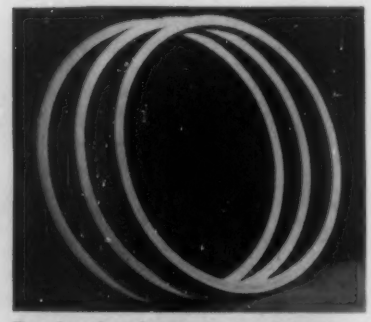
Metal-removal rate reached a peak of nearly 6000 cu in. per min. in cutting annealed 4340 at 150,000 sfm—an increase of 24,000% over the removal rate of 25 cu in. per min. which

is conventional on a good lathe. At 120,000 sfm, removal rate was 20,000% better than conventional. Better removal rates are expected.

The present program resulted from Lockheed machining tests in 1956 with a 30-cal rifle at speeds approximating those suggested by earlier plastic-deformation studies of materials at high impact. This was supplemented by a suggestion from Dr Max Kronenberg that the Air Force investigate further the tests of Dr C. Salomon of Germany, as reported by E. J. Tangerman in *American Machinist* back in 1949. Dr Salomon reported milling tests in 1931 at speeds to 55,000 sfm, which indicated that heat generated by cutting peaks out at relatively low speeds, then declines. This was in complete conflict with American theory at the time, so publication of the curves touched off a controversy, which only now is being resolved.

If further tests bear out present results, there may be radical changes in machine-tool designs, as indicated by the sketch on p 15. ■

Filament-wound Fiberglass Rings



Developed and manufactured by Apex Reinforced Plastics of Cleveland, rings give internal support to fiberglass tubes subjected to 500-psi external pressure. The ¾ by ¾ by 20-in. OD rings are wound of continuous filaments of glass fiber by passing glass through a thermosetting resin onto a split mold for support and cure. Rings are turned to give proper fit into a cylinder of dry glass, which is then centrifugally molded. End result is a tube with equally spaced ribs imbedded in the inner surface of the glass-fiber-reinforced tube. Rings contain 75% glass by weight. In this application they give 150,000-psi tensile strength (PE—July 20 '59, p 46; Jan 11 '60, p 51).

New Equation: Nuclear Students, No Reactors

WASHINGTON—As the administration's budget now stands, no funds have been included in AEC requests to provide training reactors for the nonprofit colleges and educational institutions instructing future nuclear engineers and technicians.

The backlog of universities and colleges requesting federal aid in the form of nuclear instruction reactors is about 40; the budget requested for fiscal 1961 is $2 million. At the going price of $150,000 for small training reactors, only about 10 or so colleges would be picked out as the lucky few if the commission were to grant reactors. Instead, AEC will award the amount finally apportioned by Congress for less expensive equipment and teaching aids to benefit a greater number of colleges.

Officials at AEC are somewhat alarmed at the imbalance between the number of students attending nuclear science courses on AEC fellowships in some 48 schools, and the small number of reactors to go around. They point out that in the current fiscal year, 1960, Congress cut the $3.1 million requested to $1.8 million while approving the fellowship program for about 400 students, at the level recommended. No instructional reactors are being awarded during the current fiscal year either.

When cutting back funds for equipment grants during the last session of Congress, the House Appropriations Committee recommended that research reactors already installed in campus facilities be used to train nuclear engineers. But research reactors, defined as a complex which can generate 10 kilowatts of thermal power, are too big for teaching students. The fact that training reactors and research reactors were confused as one and the same thing, AEC staffers believe, is responsible for the present dilemma.

And since Congress refused to be budged last year, the Budget Bureau has turned down AEC's request for greater funds this year and again fixed the administration's request for training reactors at $2 million, in line with the amount approved by Congress.

AEC requests for educational fellowships and scholarships for nuclear engineering training alone total $2 million for fiscal 1961. Since 1956, when the AEC initiated a program of providing nuclear equipment grants for colleges, 125 schools have been awarded $13 million, including funds for 30 teaching reactors. ■

US Appoints More Science Attaches

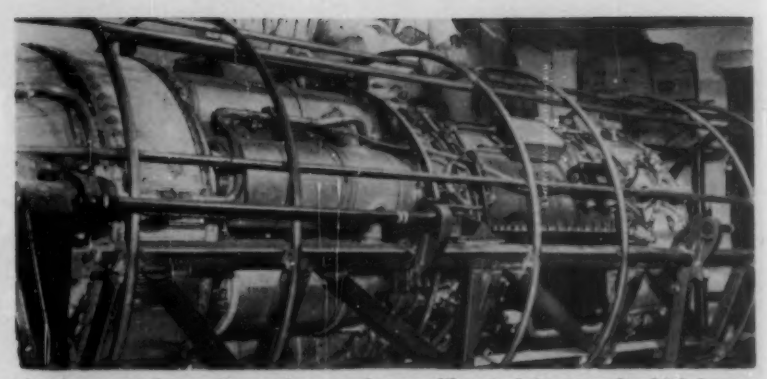
WASHINGTON—The State Department has added seven more scientists to embassy staffs. Three of the appointees have been assigned as science officers in New Delhi, Buenos Aires, and Rio de Janeiro; four as deputy science officers in London, Stockholm, New Delhi and Tokyo.

New science officers are: Ernest Watson, dean of Faculty, Calif Institute of Technology, to New Delhi; Neal Weber, prof of zoology, Swarthmore College, Buenos Aires; Harry W. Wells, chairman upper atmosphere section, Carnegie Institution of Washington, Rio de Janeiro. The new deputies: John B. Bateman, biophysicist, US Army Chemical Corps, London; William Littlewood, zoologist and oceanographer, US Navy Hydrographic Office, Stockholm; David C. Rife, International Cooperation Advisor to the Government of Thailand, and formerly prof of zoology, Ohio State Univ, New Delhi; and Marshall Crouch, prof of physics, Case Institute of Technology, Tokyo.

This is the second series of appointments (*PE—Feb 8, p 12*) made under the State Department's science program, headed by Wallace R. Brode, science advisor to the secretary. The first group went to embassies in London, Paris, Stockholm and Tokyo.

The deputy science officer, he explained, will assist the science officer, whose duties are: to advise the ambassador and his staff on science matters, keep abreast of changes in organizational structure of science in the government of the assigned country, evaluate the interaction of science with foreign policy, assess current scientific programs abroad, and encourage more friendly relations between the US and foreign scientists. ■

Jet-propelled Racing Car Aims for 500 Mph



A surplus jet engine (right) from a B-36 bomber is expected to power a racing car (scaled model left) at a speed of more than 500 mph. Designed by Ray Brock, technical editor of Hot Rod magazine, the car will be driven this summer at the Bonneville (Utah) Salt Flats by Dr Nathan Ostich, Los Angeles physician. He will attempt to break the world's land speed record of 394.2 mph. The aluminum-covered body will measure 28.5 feet long, 4 ft dia and will fit snugly around a cagelike steel framework which houses the power plant. Special nylon cord tires, 48 in. dia with 9-in. cross-sections, are being designed by Firestone Tire & Rubber Co to withstand speeds up to 600 mph. High-speed braking will be effected by a ribbon-type parachute housed in the vehicle's tail section—for speeds under 175 mph, disk brakes will be used on all four aluminum wheels. Driver is positioned between nosecone and engine.

EPA Plans Center for Soviet Translations

PARIS—If all goes well, Europe will soon have a central agency to collect and circulate translations of Soviet and Eastern European technical journals and books. A project of the European Productivity Agency, the proposed European Translation Center will be patterned after the OTS-National Science Foundation center in the US.

Activation of the proposed center hinges on agreement over working details when delegates from participating countries meet next May. As presently envisioned, the Center will stock noncommercial translations made for government and industry in participating countries. Though commercial translations will not be stocked, they will be indexed in the Center's bulletin.

The new agency is expected to be self-financing. Both Britain's Dept of Scientific and Industrial Research and Holland's National translation center at Delft have offered to house it. Both have equipment and staff to handle the anticipated workload. Operating expenses will be covered by charges for photostats.

The British translation center in DSIR now has 10,000 translations of Soviet magazine articles. DSIR receives 400 Soviet periodicals regularly and 650 occasionally. The department also has 6000 Soviet books and is adding 250 each month.

A translation-exchange agreement is under consideration between the proposed European center and the OTS-NSF center in the US. Such an agreement would give Europe access to an additional 10,000 translations. The US and European centers may also issue a joint bulletin.

A less ambitious project calls simply for an index of available translations. But sources close to EPA say that the agency prefers a full-fledged center to stock and circulate translations. ■

Soviet Small Car to Be Sold in US

NEW YORK—Assured that ample spare parts will be available, a Syracuse, NY car dealer says he'll be selling Russia's 4-cylinder 45-hp Moskvitch automobile in the US this summer. Dealer Robert J. Castle reports that his sales arrangement with the USSR calls for shipment of 10,000 units which at port of entry will be priced at $1500 each; markup is unknown.

The Moskvitch, which measures 13 ft, 4 in. long, 5 ft wide, and 5 ft, 7 in. high, has a 48-in. wheel base. It is equipped with a manual shift; 3 forward speeds plus reverse; and gives a max 43 miles per gal of fuel.

The Soviet car, shown here last year, is being sold in 30 other countries. ■

New Antiknock Is for Smaller Cars

NEW YORK—If the engine of your new compact or foreign car is knocking at low speed, the problem is probably fuel "segregation." And, according to Socony-Mobile and Esso Research tests, the answer is tetramethyl lead. TML is said to enhance antiknock properties by inhibiting that "segregation" and increasing octane rating by 2 to 6 units. But it is by no means a new chemical, as recent announcements might indicate. The late Thomas Midgley exhaustively researched it as part of the applications for basic tetraethyl lead patents.

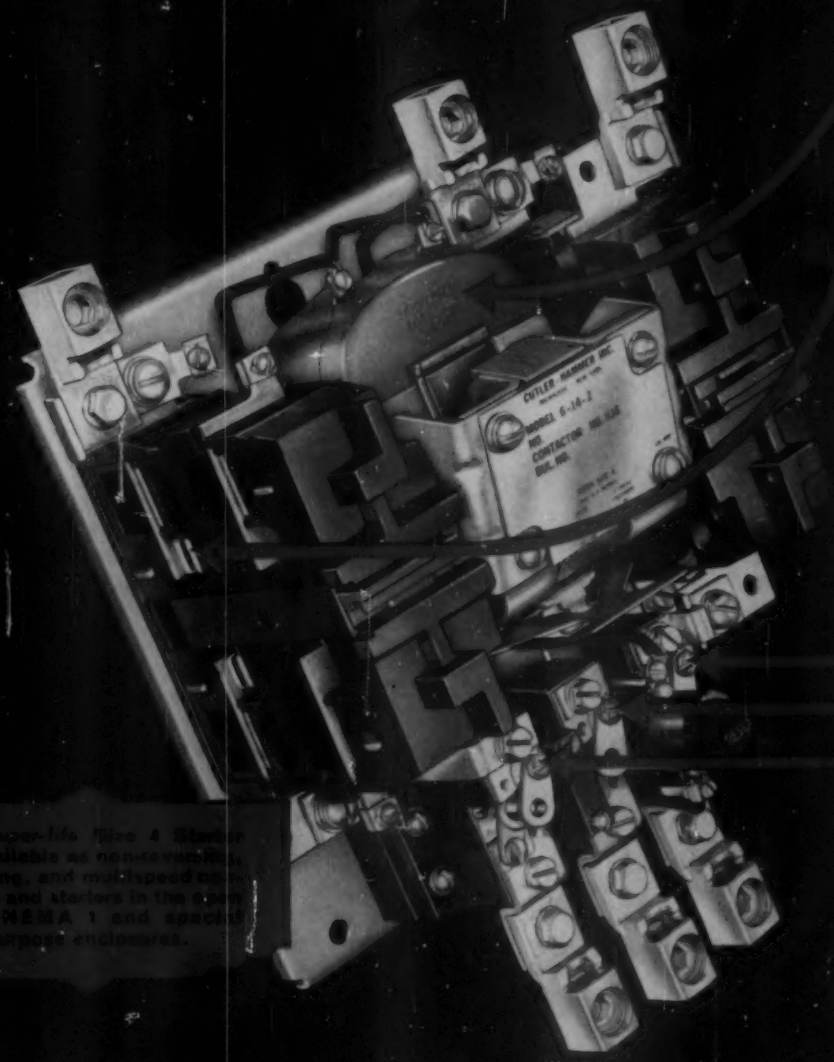
TML is a basically different molecule in which lighter methly groups replace ethyl groups. Its main outward difference is a lower voltality. This is acknowledged to be of advantage in newer engines where fuel distribution is bad at about 1000 rpm. American compacts with manual transmissions, and foreign cars, are the biggest offenders, but the problem is not as critical in Europe—European drivers know how to shift. American drivers handle small cars like a Cadillac, lugging the vehicle in low gear.

A few of the critical foreign engines include the 78-cu in. Alfa four-cyl, the Lancia V-4 and V-6, the Peugeot 403 and, in general, any engine with solex or equivalent carburetion. SU

continued on page 20

YOU CAN PROVE

Cutler-Hammer Motor Control works better . . . lasts longer



CUTLER-HAMMER

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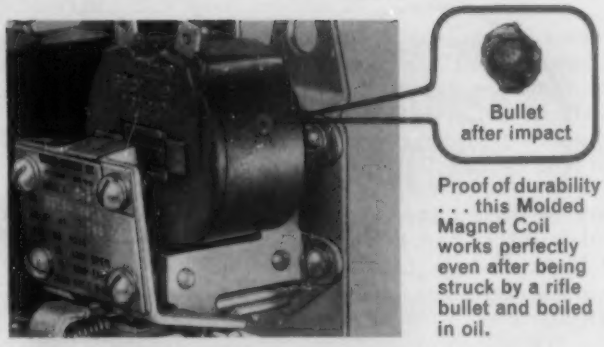
MOLDED MAGNET COILS

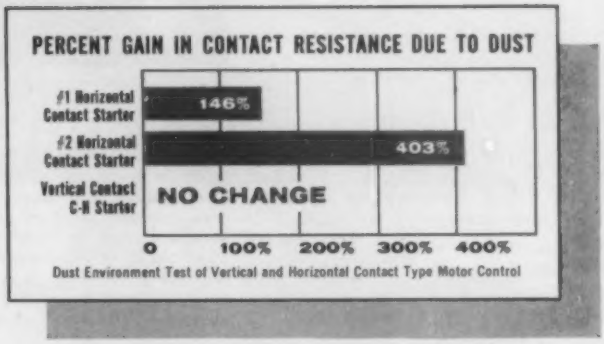
The strength and durability of the Cutler-Hammer Molded Magnet Coil is but one example of how Cutler-Hammer Motor Control is built better to last longer. Rifle bullets couldn't pierce or shatter this coil. What chance is there of it being damaged when an electrician's screwdriver slips or when the coil is dropped? Boiling oil has no effect on this coil. What chance is there of it ever being penetrated by moisture or distorted by high ambient temperatures?



Proof of durability . . . this Molded Magnet Coil works perfectly even after being struck by a rifle bullet and boiled in oil.

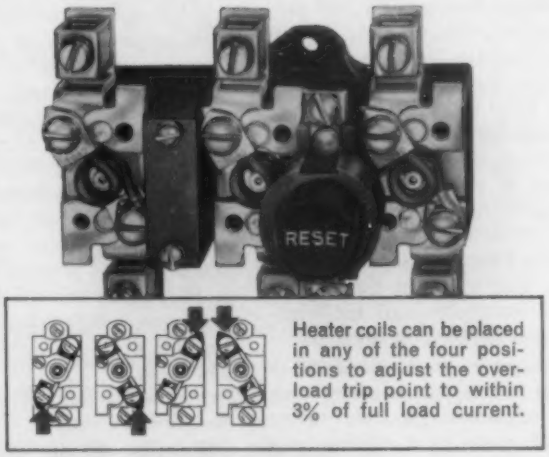
VERTICAL DUST-SAFE CONTACTS

To function properly motor control contacts *must* stay clean. And because dust can't collect on a vertical surface, only vertical contacts are truly *dust-safe*. Recent dust-chamber tests of vertical and horizontal contact type motor starters confirm this fact. After four hours of "dusting," the contact resistance of Cutler-Hammer vertical contacts remained constant. But the contact resistance of horizontal contacts skyrocketed, and as contact resistance increases so does heating, pitting, and wear resulting in rapid contact failure.



ADJUSTABLE 3-COIL OVERLOAD RELAYS

Only 3-coil overload relays can provide dependable overload protection for three-phase motors under all operating conditions. Why gamble with costly motor burnouts by using motor control that protects only two of the three motor windings? 3-coil overload relays can be provided in all standard Cutler-Hammer Motor Control, no oversize enclosures, or as an open component for low cost panel mounting. Further, Cutler-Hammer Overload Relays are adjustable to within 3% of full load motor current, not 10% or 12% as others. Cutler-Hammer Overload Relays allow the motor to work up to full capacity, provide positive protection without nuisance tripping.



Heater coils can be placed in any of the four positions to adjust the overload trip point to within 3% of full load current.

Molded magnet coils, vertical *dust-safe* contacts, and adjustable 3-coil overload relays are *plus* features that add up to bonus performance wherever Cutler-Hammer Control is used. Why settle for less when Cutler-Hammer Motor Control costs no more. Write today for Pub. EN150-C249, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

continued from page 17

carbureted engines seem to be immune to fuel segregation.

TML seems, by test, to put more antiknock into those cylinders that need it at low speed. The oil industry, in tests, notes a general increase in octane, the usable kind, on most every vehicle tested. DuPont, Ethyl, Socony and Esso could make TML in quantity within a few months. Each claims processing patents. Ethyl has quoted preliminary prices, to interested major oil companies, that run 35-40% higher per unit weight than TEL.

In general, most companies doubt that TML will be offered this year. There is considerable doubt by some that it will ever be offered, because it requires separate pumps, separate merchandising—and too low a percentage of cars needing it. ■

Predict Internships for Engineers

SAGINAW, MICH—Internships and residencies, now standard in the medical profession, may soon be adopted by the engineering profession. This prediction was made by William G. Dow, chairman, Dept of Electrical Engineering at Univ of Michigan.

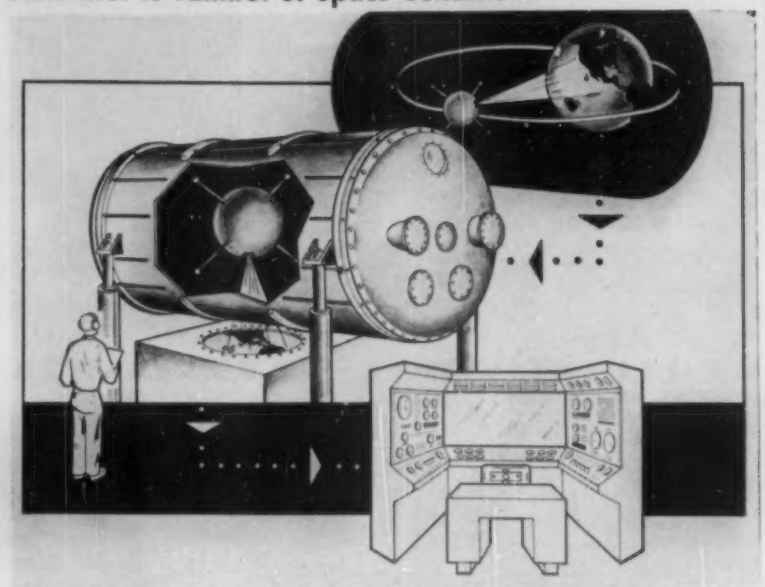
Speaking before the Northeastern Michigan section of the American Institute of Electrical Engineers, Professor Dow said that "the last 25 years have produced so much new and professionally valuable scientific knowledge that graduate-level instruction is increasingly important.

"And, we're extending our instructional resources to areas outside the campus itself and are trying to work out plans to make such off-campus graduate-level teaching more fully an integral part of the total program."

Professor Dow listed some technical advances that point up the importance of better professional and scientific training for students, such as:

- Development of devices such as transistors, thermoelectric energy converters, microwave electron tubes, plasma jets operating at extreme temperatures, and ceramics with magnetic properties.
- Reorientation of energy conversion subjects to emphasize feedback control, and concepts of self-adaption control systems. ■

Simulator Is Tankful of Space Conditions



This machine is being built for the Air Force by Minneapolis-Honeywell Regulator Co to test and evaluate US space reconnaissance equipment. Called an Advance Reconnaissance Systems Dynamic Analyzer, it will simultaneously create searing heat on one side, bitter cold on other, rarified atmospheres and rugged vibrations encountered by space vehicles. Machine will be cylindrical steel chamber measuring 15 ft long, 9 ft dia and supported on angular legs that move violently in spider-like fashion to give the chamber rolling, pitching and yawing motions. Overlooking test chamber will be two control rooms equipped with instruments to monitor, control and record the activities.

Statistics Underrate US Production

NEW YORK—US industry has been producing a greater volume of goods over the past 12 years than it thought. And it has had a rougher time in recessions and faster recoveries.

This diagnosis results from a revision of the industrial production index recently announced by the Federal Reserve Board, official purveyor of US monthly production statistics. According to the new index, industrial production has been growing at a rate of 4.1% a year instead of 3.4% as the earlier index indicated. The new series is believed a more realistic measure of the nation's productive performance.

Two factors especially contribute to the improved record. The new index includes gas and electric utilities, both rapidly growing businesses. And the board has raised estimates of worker productivity, hence calculates that they turned out a greater volume of goods.

The new index is more volatile, with sharper drops in recession and faster recoveries, because it gives greater relative importance to steel, autos and machinery. These three industries vary their production more sharply during business ups and downs than many others. ■

Soviet Census Portends Labor Shortage

Moscow—Although the latest Soviet census reflects strides in education and welfare, it also shows the potential labor shortage to be overcome if this country's ambitious goals are to be met. The preliminary statistics were released last May. Official versions of some sections have now been released —with others promised later on. Here are salient points of the official data:

- Total population on Jan 15, 1959 was 209 million—55% women, 45% men.
- Number of people with higher

educations had doubled in urban and tripled in rural areas during past 20 years. Over-all, 18 persons per thousand reportedly have higher education.

• Population shifts have been significant. For example, only 62% now in Uzbek are natives; of Kazakh, 30%. This pattern, found generally throughout the USSR, results from relocating industry during wartime and migration of Russians to construction in undeveloped areas.

The Soviet Union will have an increased percentage of old people in the next several years. The war, and impoverishment of the early 1920's and 1930's, have left an imprint on the population structure. There are now only 17 million persons between 10 and 15 years—20 years ago, there were 28 million.

Census figures also show a drop in people in the 25-to-30 and 35-to-39 age groups. This indicates Soviet labor force will shrink in the next six years.

This situation raises the question of how Premier Khrushchev will implement his promise to cut the work week from 46 to 42 hours. The shorter work week, he has said, will require 11.5 million more workers.

Observers in Moscow, who normally distrust Soviet statistics, consider this census generally accurate, because the Soviets need to know what their labor resources for long-term plans. ■

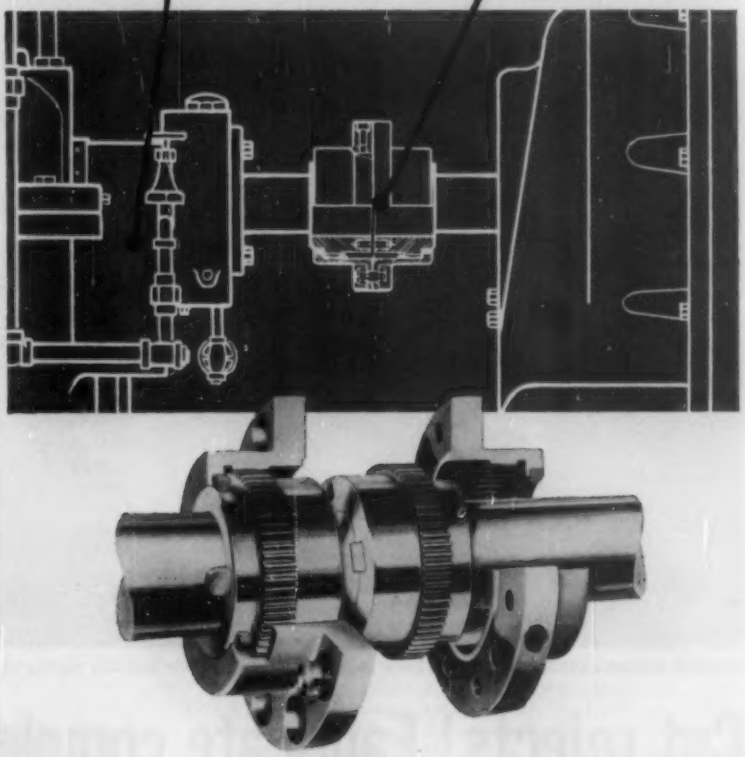
British Strengthen Technical Education

LONDON—A staff college is now being set up to improve Britain's technical education and provide better liaison between schools and industry. Sir Alexander Fleck, retiring head of Imperial Chemical Industries, is first chairman of the governing body of this joint government-industry project. His first task is heading a drive for organizational funds.

Britain's 550 technical colleges are this country's main source of scientific talent. Run by local authorities as part of the public education system, they have less rigorous entrance and attendance requirements than the universities. But standards are gradually being raised, and a few now offer a "diploma in technology"—equivalent to a US master's degree and a "membership in the college of technology"—roughly equal to a PhDd. ■

FOR "AS DESIGNED" PERFORMANCE HERE

SPECIFY WALDRON COUPLINGS HERE



When a lot of time and effort have been put into the design of a driven unit, it makes sense to protect its operating efficiency with a good coupling.

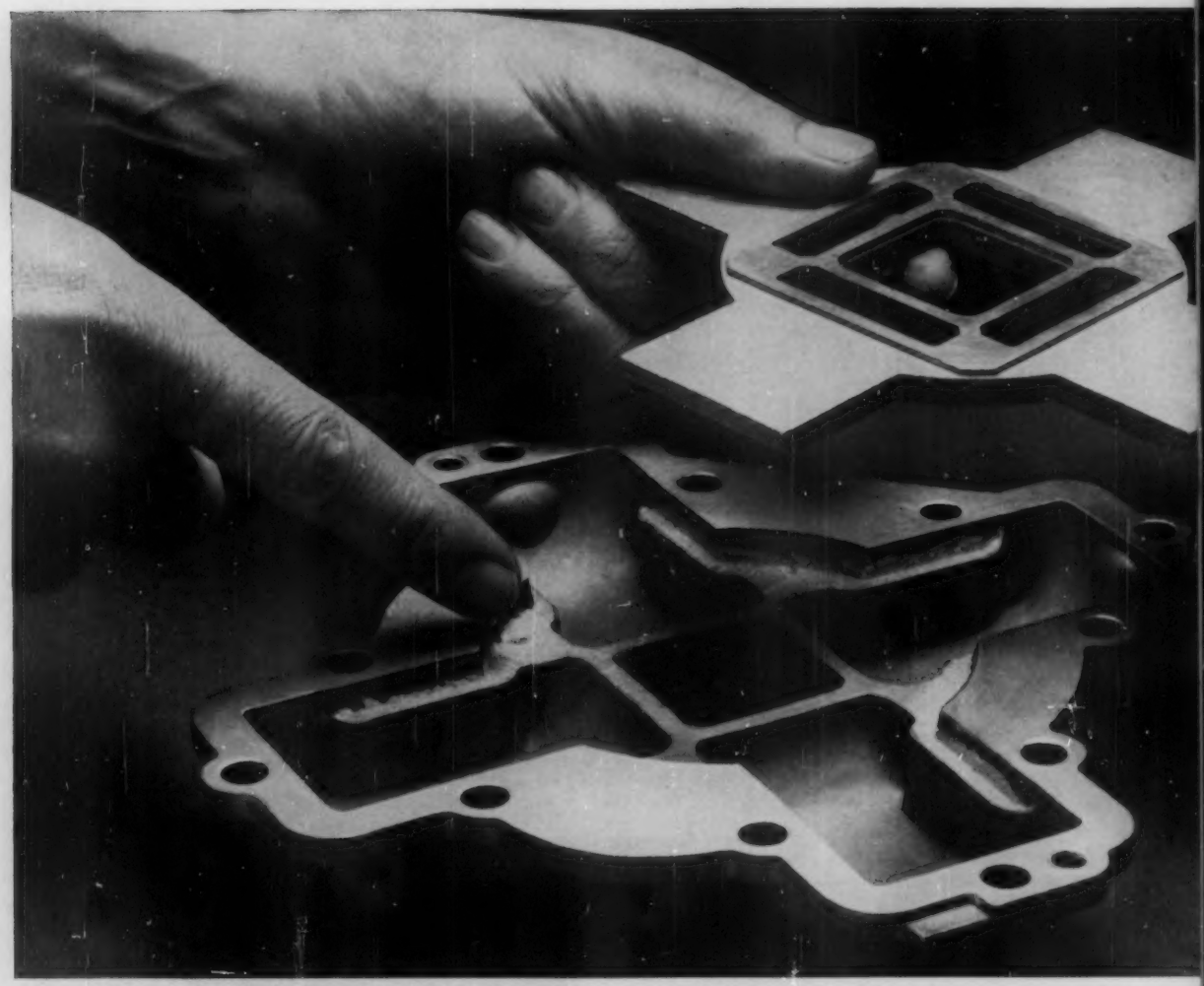
Waldron gear couplings are available in a wide range of standard and special types for any service requirement, to provide complete protection and positive, trouble-free drive.

Deliveries are excellent. Rough bore standard couplings up to 6" sizes, already assembled, can be shipped from stock; others, to meet customers' schedules.

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
P. O. Box 791 • New Brunswick, N. J.

CIRCLE 21 ON READER SERVICE CARD



SEPARATE CASTINGS, bonded together in areas indicated, form complete complex casting shown on the right.

Cut rejects! Fabricate complex castings with

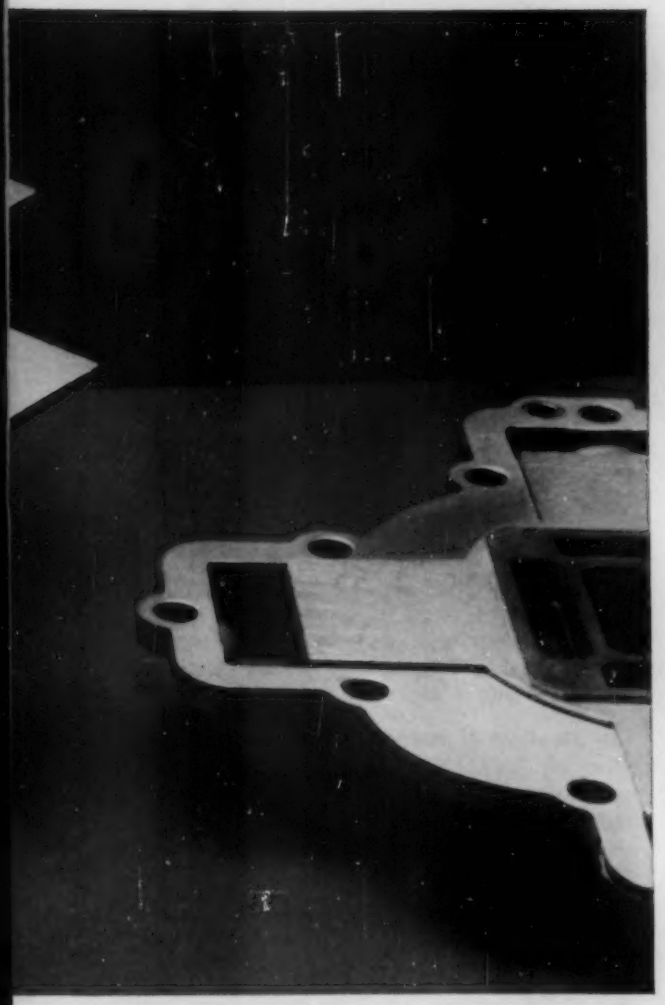
Now you can simplify production of hollow castings —and end costly rejects by casting them in sections, then bonding the sections together with high-strength SCOTCH-WELD Structural Adhesives, such as EC-1386!

By so doing, you eliminate the high rejection rate that often accompanies sand molding. You eliminate the costly machining and equipment required for mechanical fastening. You eliminate the wasteful, space-consuming bosses or flanges.

All you need is a flow gun and an oven. EC-1386 is a 100% non-volatile liquid and is solvent free. Thus, waste is negligible; no pre-drying is required before joining the sections. The adhesive bond can be cured to high ultimate strength quickly in an air-circulating oven (one to two minutes at 500°F. bond line temperature). And the cured bond can be machined for final touch-up operations. EC-1386 also serves to fill in voids, so that parts need not be held to close tolerances.

See how EC-1386 can help you cut costs, simplify and speed production and improve product quality. And learn how other 3M Adhesives are helping the metalworking industry. Contact your 3M Field Engineer. Or write: AC&S Division, 3M Company, Dept. SBS-20, St. Paul 6, Minnesota.

"SCOTCH-WELD" and "CORO-GARD" are Reg. T.M.'s of 3M Co.

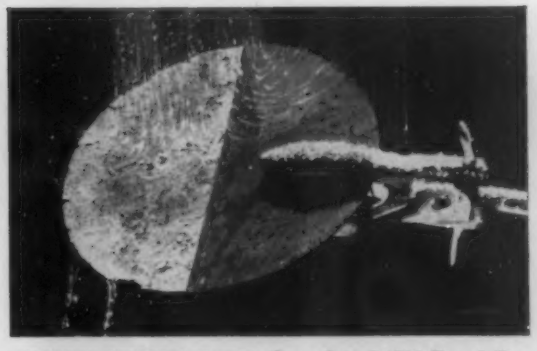


SCOTCH-WELD®

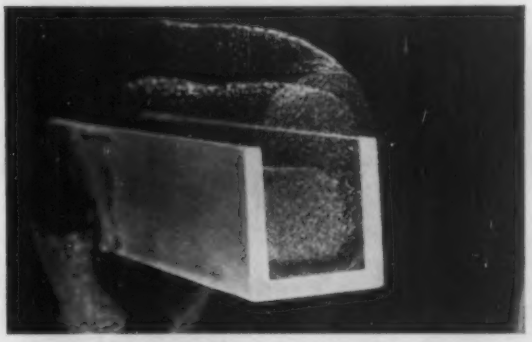
BRAND STRUCTURAL ADHESIVES

COLD SANDWICH BONDING. 3M Adhesive EC-1357 makes it possible for you to bond sandwich panels with a nip roller or cold press. You need no clamps or heated presses to complete tough core-to-skin bonds that resist moisture and high and low temperatures. This one adhesive bonds a variety of materials quickly, economically. Its dark color absorbs infrared heat quickly, dries fast.

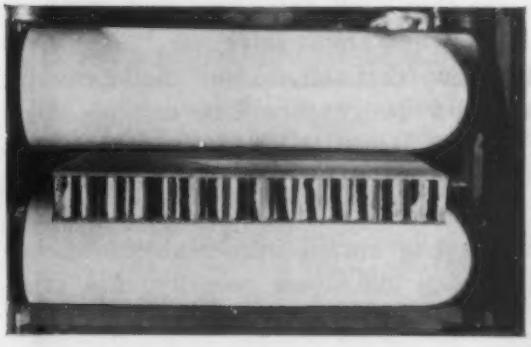
News about other 3M products



CORROSION RESISTANT COATING. CORO-GARD® 1706 Brand Protective Coating resists corrosive fluids and fumes, water and abrasion. It passed these torture tests: 2000-hour corrosive salt spray attack; 20-week submersion in 20% solution of hydrochloric acid; 6-month weather exposure in Miami, Florida. For steel, aluminum, wood, concrete, cloth, even some plastics.



SURE WAY TO SEAL. 3M Heat Expandable Sealers expand up to 125% under the normal heat of a paint-baking cycle, cure to a tough, flexible mass that keeps out dirt, water and weather, completely seal even the most irregular gap or seam. The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer and for other sealing jobs.



ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

POINTS OF VIEW

THE QUESTION: *What's it*

Dr Harold C Urey
Univ of California

Space travel, which has been sparking man's imagination for centuries, is now rapidly approaching reality. First stop, the moon! But what do we do after we land there? That brings up problems beyond designing the space ship itself—problems that engineers in many fields must solve.

To show what the various challenges are, and how designers will be tackling them, PRODUCT ENGINEERING took its questions to Dr Harold Urey who, since winning the Nobel Prize for his discovery of heavy water, has moved into fields of nuclear chemistry and, more recently, into astrochemistry and astrophysics.

Transportation on the Moon

"The surface of the moon is a sandy desert somewhat like the Sahara. Gradients will not be much steeper than 12°. Even in the mountainous areas we will find no more than a few crags—just a gradual grade everywhere. In addition, our study of lunar photographs indicates that the moon's surface has many pits covered with a dark-gray material. We do not yet know the depth of these pits, but they will obviously affect the design of any lunar car. Another feature designers will have to consider is the chemical reactivity of the moon's surface. It's under a very high vacuum and has been thoroughly de-gassed for a long period of time. It may be that we'll find solids that are pretty sticky—that the lunar vehicle may stick to this gravel. There is also the possibility that oxygen has been driven out of the surface rocks, in which case they may be chemically very active. We cannot know these things until we can actually put an instrument package on the moon."

That Question of Temperatures

"We know that temperature extremes will also have to be considered. On the surface, temperatures may vary from 100 to 125 C down to minus 100 C or more. Travelers will need to wear insulated suits to protect them from these extremes. A stroll by an individual would be quite hazardous."

Atmosphere and Gravity

"Every time we fly in one of the new jet airplanes we live in a partial vacuum—lack of an atmosphere is not too serious a problem. And the moon's low gravity will be an advantage in certain ways. Buildings can be made of lighter, even flimsy, materials. We can throw up an enormous apparatus of some kind and not have to worry about wind blowing it down. The gravity is $\frac{1}{6}$ that of the earth. This will make a big difference in the size and character of all structures. And I do not think we shall have to concern ourselves with radioactive substances on the moon —I feel that they will actually be less abundant than here on earth."

How Do You Find Water?

"I also expect that the moon's surface will contain water within the rocks as water of hydration. All we will need to do is establish a heating mechanism to raise the rocks to the temperature necessary to drive out the water. This also means that we can make oxygen without bringing it from earth. Solar reactors may eventually be used to do this, but at present, they are expensive, fragile and hard to handle. If they are successfully developed it could be a source of very cheap lunar power."

And What of Food?

"Of course all agriculture on the moon will have to take place in closed places. There is no life, as we know it,

like on the Moon?

that can survive the conditions of open lunar space. Bacteria, plants or any other living organism would be killed within a few hours by exposure to the ultraviolet rays and particle radiation on the surface of the moon. We must either take food along or attempt to grow it on the moon. And growing food on the moon will prove very troublesome because I do not think that the moon's surface is soil. We know from our experiences on earth that one cannot grow plants in fresh lava. The hydroponic growth of plants (tank farming) is not unknown on the earth and may be developed further."

Power for Lunarites

"It will be very difficult to transport major sources of energy to the moon. An atomic reactor is one possibility. Another possible source of energy that could be used on the moon, although it has never been tried on earth, is subterranean heat generated by the explosion of an H-bomb. Incidentally, I am assured by certain people that if we explode hydrogen bombs beneath the surface of the earth, we will be able to use this heat to distill water. It would be so inexpensive that we could use this water for irrigation.

"If this is true, then desert regions that lie anywhere near an ocean could all be irrigated. This, to me, is an enormously important development that certainly should be pushed as hard as it can be."

How to Get There?

"Before we can reach the moon, we'll have to develop a vehicle with a high-thrust engine. However, there is nothing impossible in the actual design of equipment necessary to put instruments on the surface of the moon. The big thing we need is an administrative decision in Washington that it shall be done, and that the cost in dollars and manpower will be paid. To me, it was simply appalling that the same week the Soviets hit the moon we cut back appropriations in our Jet Propulsion Laboratory.

"The design problems involved in this trip to space will have to be solved by today's engineers. Within several years, they will be able to get a vehicle to the moon that will transmit information back to us. However, I am very sorry to say that it looks as though the USSR is going to do the job before we do. They will do it first because they started working on space problems before we did. About ten years ago, we said it was no use talking about intercontinental ballistic missiles because the destructive range of the A-bomb was too small and the development of a precision-guidance mechanism seemed unlikely. It was the development of the H-bomb that really made the ICBM so important. The Soviet government, on the other hand, decided it would make its missiles big enough to carry large enough A-bombs to do the job. They made their decisions early and headed out in the direction of getting an enormous rocket engine."

Why Go?

"I think the whole space program will pay for itself, even if we bring back nothing from the moon—or, later, from Mars and Venus. In attempting to live and travel on the moon, for example, men will overcome Earth-world difficulties in construction and design. Transistorized apparatus will give us communication equipment that is less massive. When an enormous effort has been made to reduce the weight of apparatus to a minimum, it can be expected that many terrestrial applications of low weight apparatus will become feasible. Such applications will probably pay the entire cost of space exploration. Surely the communications satellites will further the transmission of information on the earth.

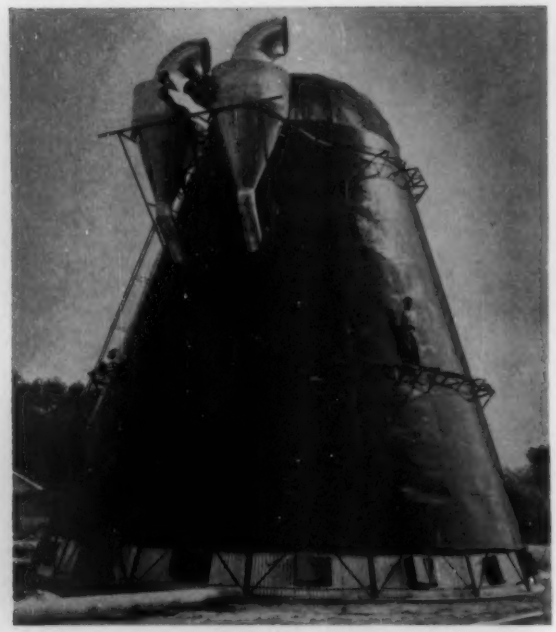
"Secondly, there is the enormous thrill we can all get. When I read about exploration to the poles, or climbing Mt. Everest, I take vicarious pleasure in these adventures. To see the back side of the moon is, to my mind, the most amazing feat of exploration since Columbus. What are we going to spend our money for in this age of the different society? Just to let someone make a car two feet longer and another foot wider? What is the use of this? I have everything I want. I do not need any more food or clothes. I am in favor of this space travel if for no other reason than sharing in a magnificent exploration.

"As far as intellectual gains go, space travel will enable us to understand much more about the origin of the universe than we have ever understood in the past. Because the moon is a dead object, it has a better preserved record of what has happened in the solar system's past than any other accessible object. Also our view of the distant stars will be greatly improved and this will enable us to learn much more in regard to the structure and active processes of the universe."

In 1934, a forty-one-year-old chemist received the Nobel Prize for discovering and isolating heavy hydrogen. The chemist was Dr. Harold C. Urey and his discovery enabled other scientists like Niels Bohr and Enrico Fermi to further study the secrets of atomic energy.

A Midwesterner by birth, Dr. Urey now holds honorary degrees from no fewer than 15 universities, and has been the recipient of 10 prizes and awards, including the Willard Gibbs Medal from the American Chemical Society and the Davy Medal from the Royal Society of London. Recently Dr Urey, now a professor at the Univ of California, has been doing research on the chemical problems of the earth's origin. This study has brought him in contact with the world's leading astronomers. Recently he had the opportunity to visit observatories in the Soviet Union. —BAL

ARMCO SPECIAL STEELS— LOW-COST ANSWERS TO



Wanted: Resistance to heat
Answer: Armco ALUMINIZED STEEL Type 1

This 40-foot refuse burner, lined with Armco ALUMINIZED STEEL Type 1, resists searing heat from burning wood chips and corn stalks. Makers of industrial incinerators and popular back-yard burners specify this special hot-dipped aluminum-coated steel because it greatly outlasts cold-rolled or galvanized steel in this punishing service.

For the same reasons, ALUMINIZED STEEL is widely used in mufflers, oven and furnace parts, and similar applications where combinations of heat and corrosion shorten life of other materials. This versatile steel is also specified for its combination of strength and heat-reflectivity in appliances, restaurant equipment, and related products.

Wanted: Top-quality porcelain enamel finish
Answer: Armco Enameling Iron

Bathtubs are drawn to a depth of 14 inches in one operation from ductile sheets of Armco Enameling Iron. Rejects stay low because this special metal is made for top performance in fabrication.

On the "firing line," too, Armco Enameling Iron minimizes defects. Freedom from impurities and resistance to sag help assure porcelain enamel products with flawless finish and close tolerances.

Summed up, "It's made *only* for porcelain enameling." That's why manufacturers of appliances, metal curtain walls, signs, and many other products specify Armco Enameling Iron for top-quality porcelain enamel finishes.

ARMCO STEEL CORPORATION, 1270 Curtis Street, Middletown, Ohio

Send me information on the following Armco Special Steels:

_____

_____

Name_____

Company_____

Street_____

City_____ Zone____ State_____

Besides the grades described, Armco produces a wide range of other special steels for better products at lower cost. These include

Armco ALUMINIZED STEEL Type 2
Armco ZINCGRIP PAINTGRIP® Steel
Armco High Strength Steel
Armco Stainless Steels (Standard and special grades in sheets, strip, plates, bars and wire)
Armco Electrical Steels
Armco Welded Steel Tubing

New steels are born at Armco

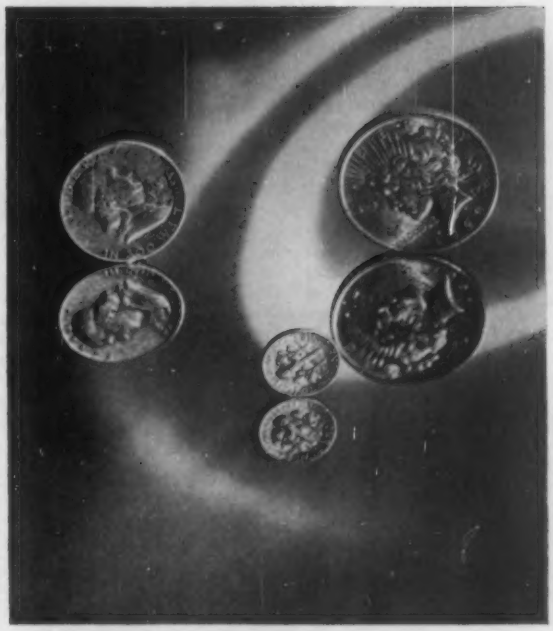
PRODUCT-PROBLEMS

Wanted: Rust-resistance, simplified production
Answer: Armco ZINCGRIP Steel

Replacement of die castings with Armco ZINCGRIP® Steel pays off four ways for a manufacturer of pressure tank air volume control valves (four center pieces in photo).

Assembly goes fast. Originally, two die-castings, diaphragm between them, were joined by bolts. Now halves are formed from ZINCGRIP Steel, diaphragm inserted, and halves joined by a reverse lockseam. *Design is simplified,* also. One valve of ZINCGRIP replaces four die-cast models. Though easier to assemble, it *costs less* and *performs better.*

Many manufacturers gain similar benefits with Armco ZINCGRIP — the rust-resisting steel that can be severely worked without flaking or peeling of its tight zinc coating.



Wanted: Economical bright-finish strip
Answer: Molding Quality Armco 17 Stainless

Three coins are easily mistaken for six when set on edge and mirrored in the bright Molding Quality Finish on Armco 17 (Type 430) Stainless Steel strip.

This high-luster finish is economical for product trim because it is a *mill finish.* Armco 17 strip is first rolled to precise thickness, then bright-annealed. In final tempering, special rolls impart the unique mirror-like quality of Armco's Molding Quality Finish.

On many formed items, the brightness of Armco Molding Quality Finish minimizes costly buffing. In addition, economical Armco 17 Stainless strip is easy to color-match with other trim materials.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

CIRCLE 27 ON READER SERVICE CARD

READER TO EDITOR

Writing and Status

To the Editor:

I was pleased by the anonymous letter at the end of your article on engineering writing in the Dec 14 issue, p 37. Your correspondent is so right! I wonder if he knows that there are two official government booklets that are outstanding criticisms of "bureaucratese" writing. Perhaps the bureaucrats will be able to destroy the monster that they helped to create.

Some management people are illiterate in that they don't recognize or appreciate good, terse English; but more often, I think, their choice of phraseology is inspired by the status factor. Arriving at the level symbolized by a spacious private office, walnut desk and secretary, a man soon discovers that he has a captive (if not captivated) audience. A change may then occur in this man, as it often does in those who become senators, successful lawyers, full professors, etc. Dynamic, terse phraseology does not seem in keeping with the feet-up, horse's mouth personality that emerges. The ponderous, impersonal phraseology, with its meaningless sonorities and endless padding, provides the epaulets and medals and funny hat for the new "Little King." It it the official court language. I hope you will continue to beat the drum for better, clearer writing, including education in writing.

—Henry J Sang
Stanford Research Institute

More on Gear Drives

To the Editor:

The article, "Overload Protection for Geared Drives" (Dec 7, p 82) did a fine job but failed to cover these points:

Where V-belt drives are used between motor and reducer, unless the torque-limiting device is mounted on the reducer input shaft it is frequently useless. Wet fluid couplings transmit equal power regardless of which member is the driver.

Wet fluid drives have the serious deficiency of being able to transmit shock loads as high as 300% of running loads. But peaks of this magnitude are quite rare, occurring only when prime-mover inertia is large and stalling time is probably in the range of $\frac{1}{10}$ second. On the other hand, the writer has run tests on car-puller applications where it was desired to find out the shock transmitted by wet fluid couplings. A 10-hp, NEMAC motor was used with a cable speed of 50 ft/min., and a cable dynamometer measured the peak tension in the cable. With the cable tied to a building support, a reading of 10,000 lb was reached when the cable was not allowed to jerk; that is, motor was started while the cable was taut. With cable lying loose on the ground, a second series of tests was made. Maximum tension under this jerking condition was approximately 11,200 lb. No tests were made without fluid coupling, though the car-puller manufacturer stated that a repetition of that type of jerk would probably break a gear.

Usually, where the wet fluid drive acts as a torque-limiting device, it transmits the breakdown torque of the motor and a small amount of motor-inertia shock. But oddly enough, these applications are successful because (1) hydraulic couplings offer a reduction in shock loads over a stiff mechinical connection which can impose 12 times' running load on the slow-speed shaft; (2) AGMA ratings allow occasional peak loads of 200% for Class 1, and 300% for Class 2 service (spur and helical gearing). AGMA also specifies a relationship among number of shock peaks per hour, and duration and magnitude of these peaks. These curves relate to endurance limit of materials. Wet fluid couplings have a dampening action which reduces the stress amplitude but raises the allowable mean stress considerably. Drives that have no slipping action cannot provide this important benefit.

—Joseph Seliber
Fluid Drive Engineering Co
Wilmette, Ill

Finagle's Law in 400 BC

To the Editor:

In a recent Publishers Postscript you made mention of Dr Finagle and his laws. In my studies, at some time or another, I ran across a similar law credited to Herodotus about 400 BC which goes, as I remember, as follows: "If one is sufficiently lavish with time, everything possible happens." The source escapes me at the time but perhaps another reader has already sent this one in, maybe even with a different author.

—Charles C Cuppy
Detroit

Liters and Quarts

To the Editor:

In Product Engineering, May '59, which I have been somewhat belated in reading, you mention the confusion between the English gallon used in Canada and the older English gallon used in the US. You suggest that the gap is too difficult to reconcile. Yet the adoption of one unit of volume measure by both countries would be quite easy.

The liter is approximately the mean of the English quart and the US quart. So, the US adoption of the liter would remove the present confusion and also avoid confusion during the transition period. For rough purposes, the liter is roughly the same as the older quart, and for precise purposes the completely different names will be unambiguous, indicating exactly which unit is meant. At the present, terms like pint, quart, fluid ounces are most ambiguous.

One point that could also be included would be the definition of a liter as 1000 cubic centimeters. The present metric litre is 1000.027 cubic centimeters. For engineering accuracy, there is no difference. But for proper relationship of units, the 1000-cc liter should be adopted. By adopting Webster's spelling of liter, the English and European people could differentiate between the old unit and the new.

—P S Carr
Geelong, Victoria, Australia

Our Editor on the Couch

To the Editor:

"Tangents" in the Nov 23 issue, p 132, reveals an interesting conflict in your Editor's personality. It would seem that he now has a complete disregard for honesty and trust, and while he is prone to blame a schoolroom incident for his "psychological bias," this does not relieve him of his current responsibilities.

Perhaps when he was 12 he could not appreciate that the pressman and his helper were embezzling the boss' money just as surely as though they were taking it from the safe, but to suggest that the time and place to learn one's liquor capacity is when you are representing your company (a position of trust) at a business meeting is beyond my limited comprehension. Judging from the description, I would guess he was the youngster. Brilliantly incoherent? Now really!

—C Stoddard
Wellsville, NY

COMING EVENTS

MARCH

6-9 . . . . American Society of Mechanical Engineers, Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston.

7-8 . . . . Steel Founders Society of America, 58th Annual Meeting, Drake Hotel, Chicago.

15-17 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac Hotel, Detroit.

29-31 . . . . American Society of Mechanical Engineers, American Power Conference, Hotel Sherman, Chicago.

APRIL

5-14 . . . . International Spring Technical Fair, Utrecht, Netherlands.

4-8 . . . . Nuclear Congress and Exhibit, New York Coliseum, NYC.

5-8 . . . . Society of Automotive Engineers, National Aeronautic Meeting, Hotel Commodore, NYC.

6-8 . . . . Institute of Environmental Sciences, 1960 National Meeting, Biltmore Hotel, Los Angeles.

7-8 . . . . American Society of Mechanical Engineers, Management Engineering Conference, Statler-Hilton Hotel, NYC.

18-19 . . . . Joint Conference on Automatic Techniques, Sheraton Hotel, Cleveland.

How Fafnir Ball Bearings help spray dryer manufacturer get

Reduced bearing costs with no loss in efficiency

In spray dryers produced by a New Jersey manufacturer for the chemical, pharmaceutical, food, and other process industries, a solution or slurry is fed through a hollow, vertical shaft and centrifuged outward into a drying chamber.

The spray is forced into a wheeling vortex by air heated to 200°F to 1000°F. The hot, turbulent air currents evaporate the water and instantaneously transform the solids into powder. The dried products and air pass from the chamber through a duct to a product collector, after which the air is exhausted to the atmosphere.

The driving source of the spray dryer is a high frequency induction motor. The motor armature is located between super-precision ball bearings. Drip feed lubrication is employed at both bearing locations. At the lower location, an aspirator prevents lubricant from working out into the machine's drying chamber.

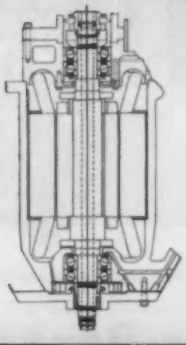
During recent redesigning, the manufacturer called on Fafnir to review proposed bearing specifications. The original design incorporated duplex pairs of super-precision bearings mounted back to back.

After studying the loading and service conditions involved, Fafnir engineers advised the manufacturer that single, spring-loaded, super-precision bearings, rather than duplex pairs, would provide the necessary capacity, support, and service life. A similar recommendation was made for a new spray dryer unit then under consideration.

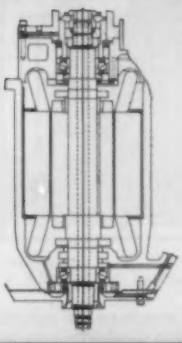
Recommendations of the Fafnir engineers were carried out resulting not only in full operating efficiency, but also effecting substantial savings in bearing costs.

This case history from Fafnir's engineering service files is typical of thousands of ball bearing problems Fafnir has helped solve for manufacturers in every field of industry. For information about the ball bearings described here, or for help with problems you may have, contact your Fafnir branch office nearest you, or write The Fafnir Bearing Company, New Britain, Conn.

Fafnir Super-Precision Ball Bearing — Preloaded, angular-contact bearings, equipped with composition retainers, are widely used in precision-built mechanisms.



BEFORE
Two duplex pairs of super-precision ball bearings were used to support the high speed shaft of this spray dryer. Redesign specifications called for use of wider type duplex pairs. The change-over was believed necessary for satisfactory shaft support.



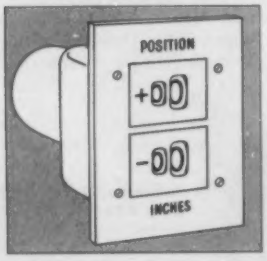
AFTER
Fafnir engineers, after a study of loadings and service conditions, advised that a single, super-precision ball bearing at each location would provide ample rigidity. The change resulted in substantial savings at no sacrifice in operating efficiency.

FAFNIR
BALL BEARINGS

Veeder-Root READOUT Bulletin

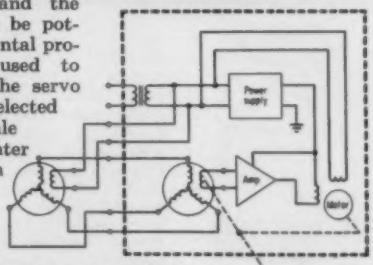
Readout Counter used in Tape Preparation for Machine Tool Control

A Veeder-Root Series 1538 Remote Data Readout Counter provides tape feed control for the motorized tape punching unit of the new Potter & Johnston Tape Control System. The tape punch is used to program machine functions on P & J Automatic Turret Lathes. The counter automatically controls the amount of tape feed required for each turret face involved, and stops the tape at preselected address points. When the correct address point is reached, a combination of holes representing the machine command is punched into the tape. Counter is automatically reset for each turret face.



Servo Repeaters Drive Counters to Indicate Lineal Motion*

One of the ways to take advantage of digital readout for indicating and recording information at remote points is through servo repeaters. Applications in aircraft, for altimeters, navigational displays and similar instrumentation, suggest many other opportunities to use counters for more positive indication and control. A typical "system" is shown here where a counter is used for indicating nuclear reactor rod position. The servo repeater and counter actually form one packaged unit, and the whole device can be potted for environmental protection. When used to drive counters, the servo gear ratio is best selected to provide full scale travel of the counter for one revolution of the control transformer shaft.



Typical servo repeater/counter device that converts synchro data to digital readout.

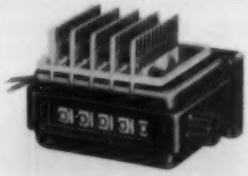
Let Veeder-Root help you make Counters do more! Extensive design experience and precision production techniques make it possible for Veeder-Root to help you solve a wide variety of digital, readout, control and recording problems with counters — from the simplest ratchet to advanced readout and navigational devices. Send for information on specific applications or contact your local Veeder-Root Counting Engineer.

*Reprinted from CONTROL ENGINEERING June 1959. Copyright© 1959 by McGraw-Hill Pub. Co., Inc. All rights reserved.

Veeder-Root Readout Device

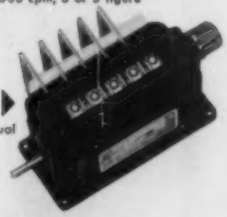
This is the basic series of Remote Data Readout Counters. Some are available for standard applications, or design variations will be submitted based on requirements. They function basically as analog to digital converters.

Series 1538/electrical reset/electrically actuated. Speed 1000 cpm, 3 or 5 figure



Series 1538/electrically actuated/manual reset. Speed 1000 cpm, 3 or 5 figure

Series 1606/mechanically actuated manual reset standard; bi-directional (non-reset) available. Speed 5000 cpm, up to 5 figures



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St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal
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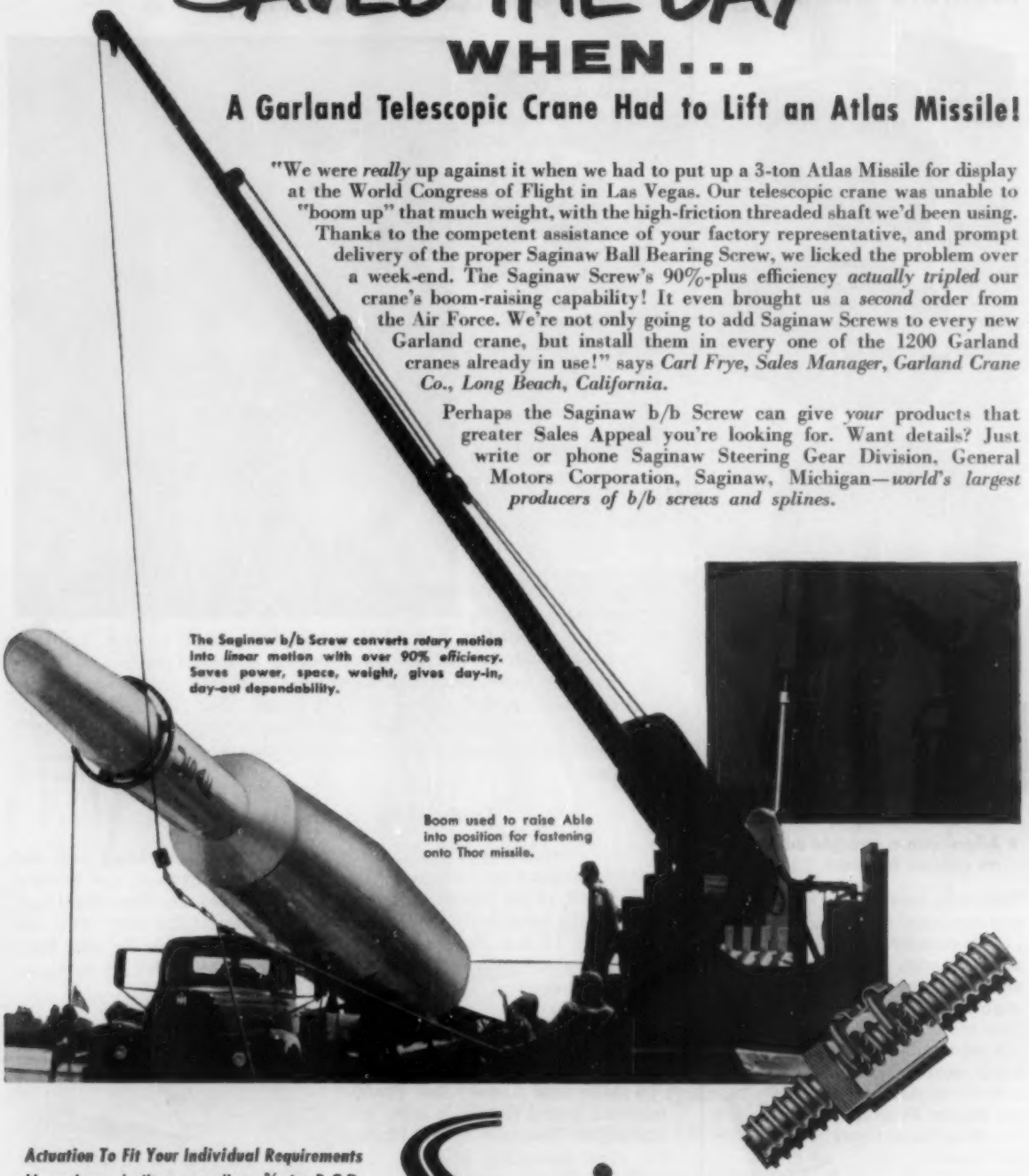
THE SAGINAW b/b SCREW SAVED THE DAY WHEN...

A Garland Telescopic Crane Had to Lift an Atlas Missile!

"We were *really* up against it when we had to put up a 3-ton Atlas Missile for display at the World Congress of Flight in Las Vegas. Our telescopic crane was unable to "boom up" that much weight, with the high-friction threaded shaft we'd been using. Thanks to the competent assistance of your factory representative, and prompt delivery of the proper Saginaw Ball Bearing Screw, we licked the problem over a week-end. The Saginaw Screw's 90%-plus efficiency *actually tripled* our crane's boom-raising capability! It even brought us a *second* order from the Air Force. We're not only going to add Saginaw Screws to every new Garland crane, but install them in every one of the 1200 Garland cranes already in use!" says *Carl Frye, Sales Manager, Garland Crane Co., Long Beach, California.*

Perhaps the Saginaw b/b Screw can give *your* products that greater Sales Appeal you're looking for. Want details? Just write or phone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*



The Saginaw b/b Screw converts *rotary* motion into *linear* motion with over 90% efficiency. Saves power, space, weight, gives day-in, day-out dependability.

Boom used to raise Able into position for fastening onto Thor missile.

Actuation To Fit Your Individual Requirements

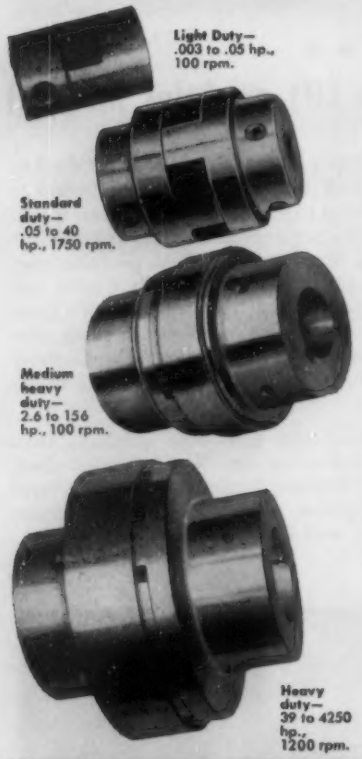
Have been built as small as 3/16 in. B.C.D. and 1½ in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.

Saginaw ball bearing Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE

Lovejoy

Flexible Couplings



from .003 to 4250 H. P.
⅛ In. to over 9½ In. Bores

- **Can be installed in minutes**
- **Align with a straight edge—no gauges required**

The most trouble-free couplings you can install on your equipment . . . no complicated mechanisms, all parts open for inspection, reversible cushions, no lubrication required. Immediate delivery from stock in any quantity.

Send us your requirements for quick recommendations and prices. Ask about our helpful Flexible Coupling Guide Sheet and request Catalog C-56.

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Telephone: EStebrook 9-3010

FOR YOUR INFORMATION (personal)

Satellites perform for you

Want to see Sputnik II and Discoverer V go through their appointed rounds? Orbit-watching will be easy when films, now being made by a special electronic process, become generally available.

The process, developed at Rensselaer Polytechnic Institute, uses a "satellite simulator" to generate programmed signals that can be picked up by a projection oscilloscope. The scope, in turn, projects a bright spot which is made to orbit around a relief model of the earth (see photo). Speed of movement of the spot is controlled by an electronic speed synthesizer. It simulates the speed of any satellite at a specific distance from the center of the earth.

The system can be used for direct viewing or for production of motion pictures, using multiplexing equipment, that bring the satellite image into proper relationships with that of the earth model. One such film has already been made and two more are scheduled. When the series is complete, they'll be made available through regular distribution channels.

Tattles your innermost secrets

Those broadcasting pills, long predicted, are now actually being built and tested in England, as well as the US, East & West Germany, and Sweden. H. S. Wolff, of the National Institute of Medical Research, Hampstead, London, says the latest British "pills" are tiny signal-transmitters only 7 to 8 mm in dia and 15 mm long. They move quite easily through the alimentary canal, sending out information on temperature, acidity and other key indicators of intestinal function.

Hot-shot hammer

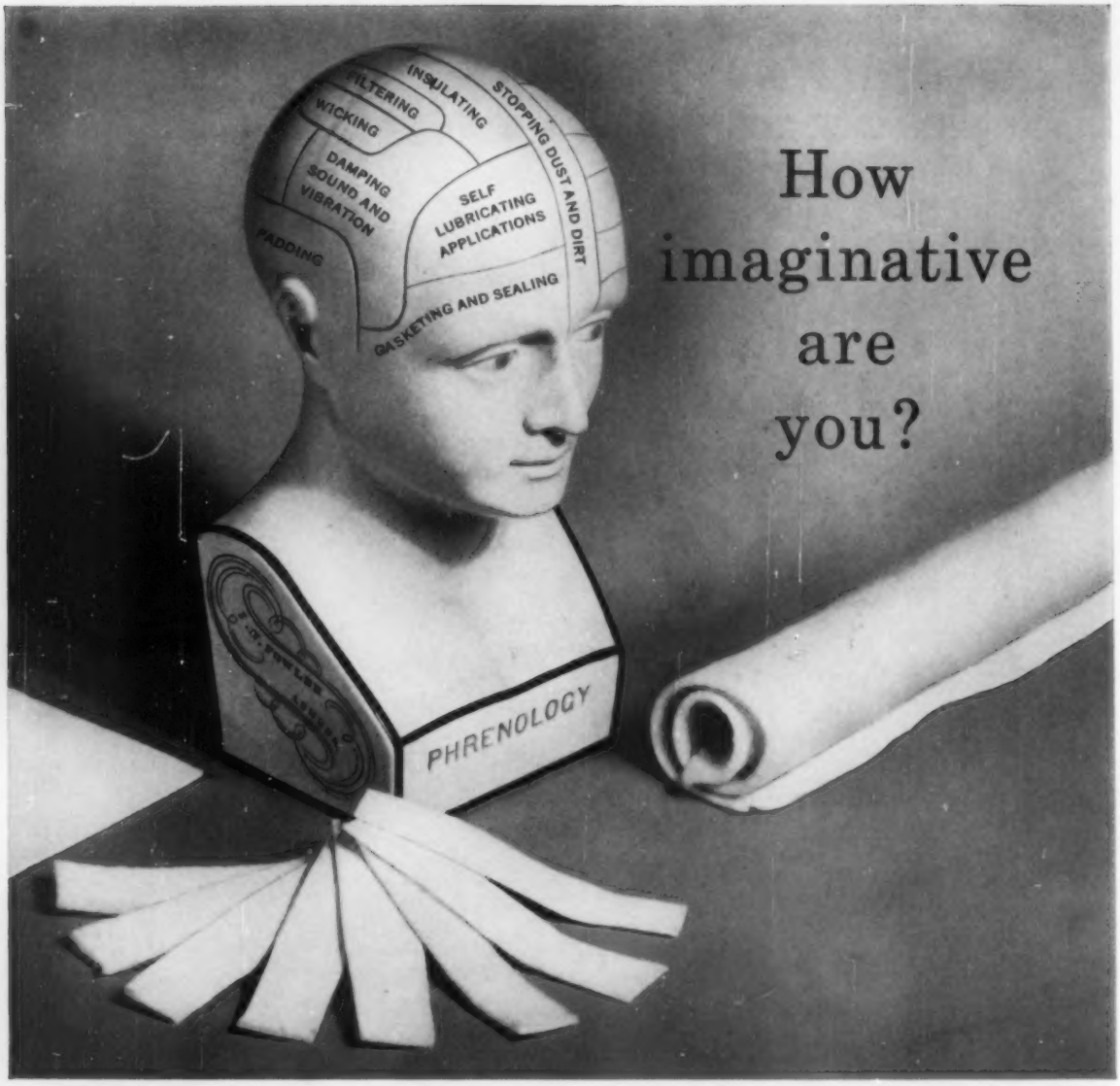
A shot-loaded hammer that should minimize busted thumbs is being introduced by Metocraft Alloy & Plastic Co, West Springfield, Mass.

The hammer has replaceable plastic tips and a central aluminum head, divided into two cavities that are filled with lead shot to minimize rebound. First size to be introduced, with a 1⅛ by 5 in. head, weighs ¾ lb, is priced at $5.60. —ARG

have you seen all that's new in gleaming stainless steel?

Now, leading department stores everywhere are showing gleaming, carefree Stainless Steel in new and exciting displays. See these shining examples of Stainless Steel kitchenware, tableware, utensils and appliances to make your living easier. *McLouth Steel Corporation, Detroit 17, Michigan*

McLOUTH STAINLESS STEEL



Troyfelt, a family of synthetic felts in non-woven form, offers Dacron and Orlon in an entirely new dimension!

TROYFELT is a non-woven synthetic felt manufactured by an exclusive process which *mechanically interlocks* the fibers rather than relying on a binder chemical or fiber. This results in a *uniformly* stronger material with fewer design limitations.

We can make it to your specification for thickness, density or permeability. We can make it to match SAE specifications for thickness, weight and density. We can make it out of straight Dacron, Orlon or a blend.

You can use it for stopping or collecting dust or dirt...for polishing...for damping sound and vibration...for self lubricating applications...for padding ...for gasketing and sealing...for insulating...for wicking. Anywhere a natural felt is not doing precisely the job you want...wherever you need greater strength and abrasion-, chemical- and heat-resistance — TROYFELT offers the complete solution. And, because it can be made in so many different forms, about the only limit to its use is your own imagination.

We'd be glad to send you our just-published bulletin and samples of the material. It describes typical applications and gives detailed tables of properties.

TROYFELT ... *by the pioneers in non-woven synthetic felts*

INDUSTRIAL PRODUCTS DIVISION • TROY BLANKET MILLS

200 Madison Avenue • New York 16, New York

HOW CAN NICE HELP YOU?

NICE offers...

. . . complete lines of precision, semi-precision and unground standard bearings.

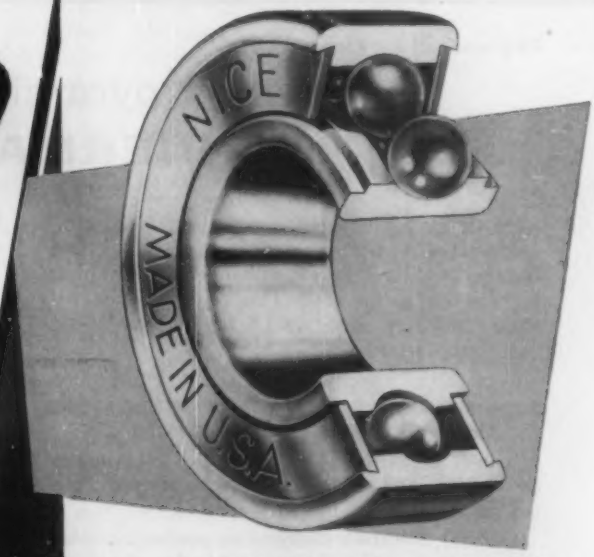
. . . facilities and "know-how" to design and produce "specials" to exactly suit individual bearing application requirements.

. . . standard and special bearings that offer Product Designers many design improvement and cost-saving opportunities.

. . . bearings that have proved their economic and performance value in the accepted products of many hundreds of well-known manufacturers.

. . . NOW . . . the revolutionary new UNIBAL, a low cost bearing of superior quality, suitable for many precision bearing applications. UNIBAL construction features solid inner and outer raceways, with deep, unbroken ball grooves and a full complement of balls. Unique new and patented manufacturing methods produce bearings of exceptional durability and strength.

How can NICE help YOU?



As illustrated above, the new UNIBAL Ball Bearing features solid inner and outer raceways, with deep, unbroken ball grooves, *plus* a full complement of balls.

NICE

NICE BALL BEARING COMPANY
DIVISION OF CHANNING CORPORATION
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CIRCLE 35 ON READER SERVICE CARD

Engineered by Tinnerman...

Savings pyramided 68% by a switch to TINNERMAN SPEED NUTS®

First, the saving in material on the General Electric Dishwasher... a Tinnerman SPEED NUT brand fastener is formed right in a channel stamped from high-carbon spring steel. This replaces a costly solid steel bar formerly used to mount the pull-out basket rollers.

Next, the Tinnerman SPEED NUT impressions are stamped right in the channel; expensive boring and tapping of the bar stock are eliminated.

Third, sheet metal screws hold tight in the SPEED NUT, and are easier to start and drive than the machine screws formerly used.

General Electric's dishwasher production goes faster and assembly costs are reduced by the easy-to-apply feature of the simplified SPEED NUT part. The difference in weight even makes an important reduction in freight costs on each carload shipment of dishwashers.

What Tinnerman SPEED NUTS accomplished for General Electric can probably be done for you.

A call to your Tinnerman Sales Representative will be the start. He's in the Yellow Pages under "Fasteners".

Or write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Macano-Bundy GmbH, Heidelberg.

PRODUCT ENGINEERING HORIZONS

February 29, 1960

LIFE ISN'T A STATISTIC

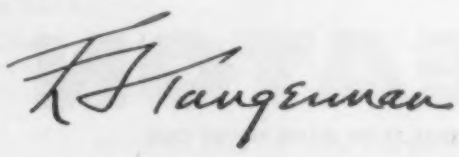
Two recent "discoveries" touted in the newspapers seem scarcely to be discoveries at all. One is the august conclusion that people mature and age in spurts, the other that the economy grows from new products in profusion, not from inflation or a major new industry or from money. The next discovery, to be similarly heralded, no doubt, by the sages of those two "soft" sciences, medicine and economics, is that people and products are interrelated, that there are "dwell" periods in economic development just as there are in personal development. And the "dwell" periods are not stagnation as much as they are re-muscling.

Take the Thirties, for example—your own, or the nation's. In your own, you've passed the first flush of youth and are gathering for a real spring at success. In the nation's, those stagnant Thirties were the years when Einstein, Fermi, Lawrence and others were doing their big work—the work on which most of our present advances are based.

There's nothing so startling in this; ordinary people have known it for years. It's just that the experts have now provided a formula and a law, like the weather men who find out the Farmer's Almanac was right all along, or the medical researcher who discovers that Grandma's remedies weren't nearly as superstitious as they were practical. They feel better when they have a formula—even a post-development one.

The funny thing about people is that they try to imitate machines. All of us are busily trying to work out laws and rules and formulas to apply to everything, but only the "hard" sciences and inanimate things operate that way. The "experts" on automobile and appliance selling, on TV viewing and a host of other things, are finding that out. As my old college dean once said, "There are three kinds of lies: plain lies, damned lies, and statistics." Put the statistics down and admire them, but if animate things are involved, don't gamble on them—you'll lose. This is perhaps merely a re-statement of Gumperson's or Finagle's laws, which themselves reflect our good-humored realization that prediction is a hazardous thing.

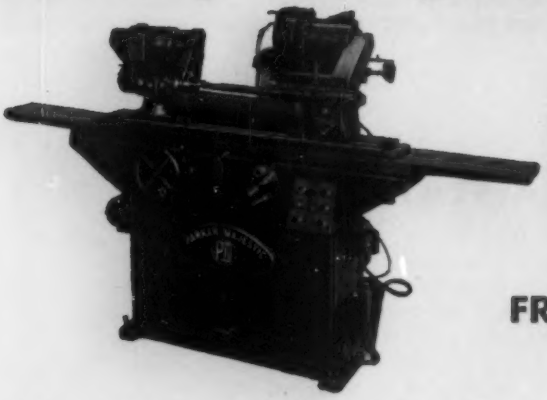
Perhaps the basic thought here is that life itself is still the mystery that surpasses all mortality tables. And life is concerned with creation (creativity) nutrition (research) and health (acceptance)—even genes (genius)—whether it's a person or a product. The statistics can only be the record, not the prediction.



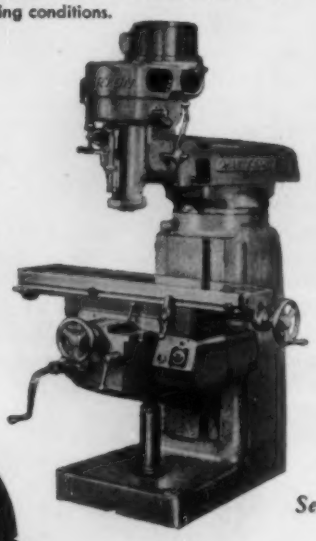
Need Infinite Speed Adjustment—Accurate Control?

Get Both with DYNAMATIC®

FRACTIONAL HORSEPOWER AJUSTO-SPEDE® DRIVES



Parker Majestic No. 2 Universal Grinder is equipped with two Ajusto-Spede Drives. One drive, mounted on the headstock, rotates the work against the grinding wheel. Another drive operates the table feed. Both work speed and table speed are infinitely adjustable to suit varying conditions.



A Dynamatic Ajusto-Spede Drive provides infinitely adjustable table feed speeds on a Gorton Mastermil. Stepless adjustment permits the operator to select the proper table speed for maximum efficiency in machining all metals.

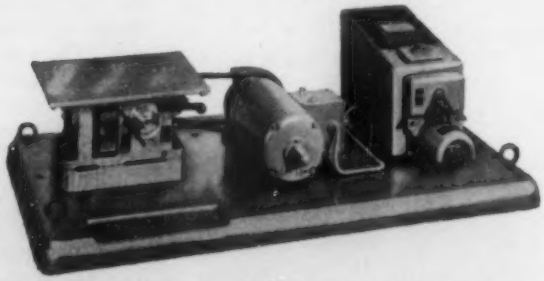
Wherever infinite adjustment and accurate control of speed are required for proper machine operation, satisfied users are realizing improved machine performance and product quality through the use of Dynamatic Ajusto-Spede Drives. Stepless adjustment from zero to full output speed, and accurate control of any speed within the range, permit operation at the exact speeds required.

Ajusto-Spede Drives operate on standard 115/220 volt alternating current, requiring no special power source. The compact drive with its integral control system needs no wall space, and requires little space on the driven machine. These drives may be mounted in any position, providing great versatility of application. Twelve models are available in ratings from 1/4 hp at 1650 rpm through 1 hp at 3200 rpm.

Before you specify a fractional horsepower drive for your product or plant equipment, check the many advantages offered in the Dynamatic Ajusto-Spede Drive.

Send for Your Free Copy of Illustrated Bulletin FAS-6 which Describes Dynamatic Ajusto-Spede Drives

Harnischfeger Welding Positioner WP-1 uses an Ajusto-Spede Drive and gear reducer to rotate welding table. Table speeds are infinitely adjustable from zero rpm to 4.47 rpm. Drive tilts with table to the position desired by the operator.

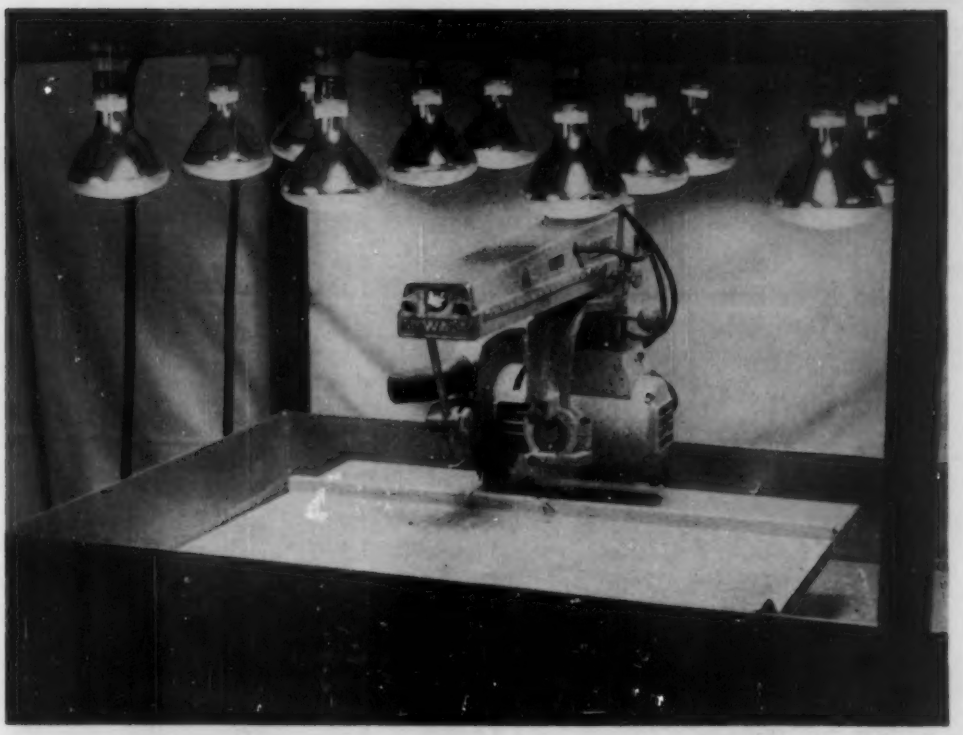


Vibration Fatigue Testing Machine manufactured by the All American Tool and Mfg. Company employs an Ajusto-Spede Drive to operate a vibrating table at various speeds for testing instruments and electrical components.

EATON

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN



Warpage test is one of several that reveal characteristics of composition board. Here, infrared heats upper side of composition table top to 200 F while water in tank keeps lower side wet. This moisture-gradient test is made with saw in operating position.

your selection guide to

BONDED WOOD COMPOSITION BOARDS

Mechanical properties aren't the only way to judge "compo" boards. Moisture absorption and dimensional stability, too, must often determine the choice.

CHARLES W McMILLIN, *research engineer*
Central Research Laboratory
American Machine and Foundry Co

Nature produces a fairly good structural material when she grows trees—but technology goes farther. It takes the wood particles and bonds them together for a uniformity that does not depend on type of grain and various natural deficiencies. Besides giving uniformity, bonding the wood with adhesives also can increase dimensional stability, wear-resistance and resistance to moisture.

But these improvements bring confusion—that of tradenames. The wide variety of proprietary wood compositions are sold with little or nothing to guide the buyer as to what they are, how they are made, or what properties might be expected. Our interest in the problem started when we had to evaluate a variety of wood composition boards in order to select the right material for the table top on our DeWalt radial-arm saw.

The two more important performance properties of "compo" boards are: (1) mechanical strength; (2) dimensional stability and freedom from warping. Generally, such properties can be estimated from the type, kind and distribution of particles, how they are bonded, kind and amount of adhesive, and the subsequent treatment. Because of the many types of composition boards available, usually one can be found adequate to the job.

THESE TYPES

Wood composition boards can be classified roughly into the following groups:

Hardboards are made from wood fibers that have been steamed or mechanically ground from logs. Heat and pressure cause the natural lignin to bond the fibers into

REPRINTED—Circle P36, inside back cover

COMPARISON OF HARDBOARD PROPERTIES

	Manufacturer	Tradename	Thickness, in.	Sp. gr.	Flexure Strength, psi	Tensile Strength, psi	Water Absorp., %, 24 hr
STANDARD	Anacortes Veneer	Armorbord	1/8	1.00	6500	—	20
			1/4	1.05	6500	—	16
			3/16	1.08	6500	—	12
		(medium density)	3/16, 1/4	1.00	4500	—	15–20
	Cascades Plywood	L-30	1/10 to 3/8	1.08	5700	—	18–6
		PL-90	1/10 to 3/8	1.12	6900	—	12–5
	Edward Hines Lumber	Allwood	1/8 to 1/4	0.98	5500	—	20–16
		Prest-panel	3/16	0.92	3800	—	25
			1/4	0.89	3000	—	30
	Evans Products	Smooth-bord	1/8	0.96	6400	3700	16
			1/4	0.96	6500	3500	12
			3/16	0.98	6800	3900	15
	Forest Fiber Products	Forest Board	1/8, 3/16	1.0	6000	3000	17
			1/4	1.0	5500	2900	16
	Georgia Pacific	Georgia Pac. Hardboard	3/32 to 3/8	1.08	6000	—	15–7
	Masonite	Presdwood	1/10 to 5/16	1.01	6000	3000	9–16
		Duolux	1/8 to 3/16	1.09	9000	5000	16
		Duolux	1/8	1.08	8000	3800	7
		Seadrift	1/4	1.08	9000	4000	7
		Royalcote	1/4	0.90	4500	2300	15
	US Gypsum	Duron 10	0.01	1.12	8500	—	18
		12	0.135	1.12	7000	3500	20
		18	0.180	0.99	6300	3800	20
		25	0.24	1.04	6000	—	14
	Weyerhaeuser Timber	Weytex	1/12 to 5/16	1.00	6500	4000	8–30
		Weylec	1/12 to 5/16	1.05	8500	4500	—
TEMPERED	Cascades Plywood	UL-50	1/10 to 1/4	1.0	4000	—	28–14
	Edward Hines Lumber	Tempered	1/8	1.02	9000	—	15
		Allwood	3/16	1.04	9000	—	12
			1/4	1.04	8500	—	10
	Forest Fiber Products	Temix-treated	1/8, 3/16	1.02	9000	5200	9
			1/4	1.02	8500	4600	7
			3/8	0.80	4500	2000	9
	Masonite	Presdwood	1/10 to 5/16	1.08	10000	4000	5–13
		Duolux	1/8, 1/4	1.10	9500	5300	6–7
		Ridgline	1/4, 5/16	1.08	9000	4000	6–7
		Ridgegroove	5/16	1.08	8300	3800	6–7
		Leatherwood	1/8	1.10	9500	5300	7
		Lofting Board	1/8	1.21	11000	6100	6
		Benelux 70	1/4 to 2	1.40	12500	7700	1
		" 30	3/8 to 1 1/4	1.23	6700	—	2
	US Gypsum	Duron 12-T	0.135	1.18	9000	5000	12
		18-T	0.180	1.05	7500	5300	12
		22-ST	0.225	1.13	5000	—	18
		25-T	0.240	1.08	7500	—	10
	Weyerhaeuser Timber	Weytex	1/12 to 5/16	1.05	8500	4500	8–30
		Weyfair	1/8 to 1/4	1.05	8500	4500	10–16

COMPARISON OF PARTICLE-BOARD PROPERTIES

	Manufacturer	Tradename	Thickness, in.	Sp. gr.	Flexure Strength, psi	Screw-holding Power, lb	Water Absorp., %, 24 hr
FLAKE	Abitibi Power & Paper	Platewood	3/16 to 1 1/8	0.60	3200	350	18
	Carolina Forest Products	Flakebond	3/8 to 1 1/8	0.64	3500	330	23
	CFI Boards	CFI 685	1/4	0.64	2800	200	15
		CFI 585	1/4 to 3/4	0.64	4350	300	18
	Columbia Hardboard	Cedawood	3/16 to 3/4	0.67	3700	263	19
	Gray Products	Graco	1/2 to 1 3/16	0.65	3500	300	10
	International Paper	Veno wood	1/4	0.90	4000	—	16
		Flake-wood	1/4	0.93	4000	—	20
	Pope and Talbot	Flake-board	3/8 to 1	0.64	3500	300	18
	Tenex	Tenex	1/4	0.70	3000	73	25
		Packy	1/4 to 5/8	0.65	2300	225	25
	US Plywood	Novaply	3/8 to 2	0.67	2800	250	—
	West Virginia Paper and Pulp	West-vaco	1/2 to 3/4	0.64	4000	275	15
GRANULE	Carolina Forest Products	Shav Bond	5/8, 3/4	0.74	2243	330	15
	CFI Boards	CFI 946	3/4	0.70	3500	250	9
		CFI 984	1/4	0.64	1900	200	9
	Gray Products	Graco	5/8	0.64	1600	300	10
	Pacific Plywood	Parwood	1/4 to 3/4	0.64	1700	225	12
		Partex	1/4 to 3/4	0.70	2100	250	10
		Parform	1/2 to 3/4	0.77	2400	275	10
		Partile	1/4	0.88	3800	—	8
	Souhegan Wood Products	Plaswood	5/8	0.67	1600	200	15
	Southern Plaswood	Plaswood	5/8	0.67	1600	300	20
		Korstok	1/2 to 1 1/4	0.90	2100	385	15
	Wabash Screen Door	Wabash	1/4 to 7/8	0.67	1500	250	24
	West Virginia Paper and Pulp	Westwood	1/4 to 3/4	0.65	2000	270	10
	Wynne Wood Products	601	3/8 to 1	0.99	4000	800	10
CHIP and SPLINTER	Cavalier Corp	Ligna-Bond	3/8 to 7/8	.70	1600	680	19
	CFI Boards	CFI 341	3/8 to 3/4	0.64	1700	200	9
		CFI 441	5/16 to 3/4	0.64	2250	215	9
		CFI 383	1/4 to 3/4	0.64	1800	200	12
	Chapwood	Premium	1/2 to 5/8	0.70	2400	246	33
	Clear Fir Sales	Clear Fir	1/4	0.95	4500	—	9
	Dixie Chipboard	Chipboard	1/2 to 2	0.68	1500	450	—
	Granite Board Div	———	3/8 to 1 1/8	0.65	1700	225	20
	Pope & Talbot	Particle Board	1/4 to 1	0.64	2000	250	15
	Roddis Plywood	Tim Blend	3/8 to 1 1/8	0.65	3500	—	—
	US Korboard	Korboard	1/2 to 2	0.64	1900	300	50

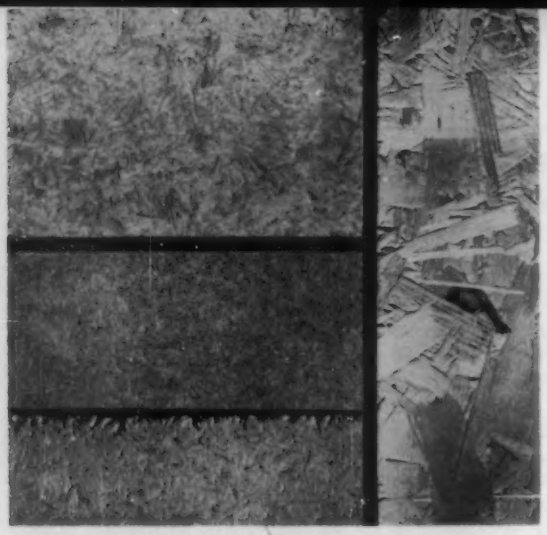
sheets up to ¾ in. thick. The mechanically ground fibers are adhesive-bonded in a dry process. The tempered types of hardboards have additional oil that add moisture resistance, hardness and abrasion resistance. Some hardboards are given plastic coatings to improve these properties.

Particle boards consist of a variety of granules, splinters or flakelike chips. These elements may be separate, mixed, or in layers. To form a board, the particles are mixed with adhesive and bonded together under heat and pressure.

Composites consist of particle board, plywood or other materials as a structural core and hardboards or particle boards as facing materials. Generally, the materials are chosen for improved abrasion resistance at the surface and high strength-to-weight ratios, as well as dimensional stability imparted by the core. Particle boards that are made in layers can be considered composites within themselves. For example, a granular center with flakes and higher resin content at each surface. This puts a strong, dense flake structure at the outer fibers.

PROPERTIES DEPEND ON PROCESS

Some "compo" boards are pressed; others are extruded. Pressing makes the intertwined fibers lay parallel to the plane of the board. Extrusion packs the fibers perpendicular to the direction of extrusion. In general, flat-pressed boards have the greater strength in bending, but show



ATTRACTIVE SURFACE TEXTURES are shown by these bonded-wood compositions. Clockwise from right: boards made from flakes, granules, fibers, and fine flakes.

more change in thickness with changes in moisture content. Extruded boards, on the other hand, have less bending strength in one direction, and their dimensional change is in the form of elongation. Usually the extruded boards are laminated with a veneer overlay or other higher strength material.

CHOICE DEPENDS ON APPLICATION

When evaluating wood composition board for a given application, first determine what properties are important and set realistic specifications for performance. For example, high mechanical strength is more important than dimensional stability where a board is to support a heavy load in a relatively dry area. But where moisture is high, swelling might cause the board to interfere with other parts or even put stresses on them.

Board density is the tipoff because it influences other properties. Mechanical strength increases with density and machinability is improved—as well as screw-holding and nail-holding ability. Although the high-density boards are stronger, their dimensional stability is less.

Strength requirements of the end-use should then be determined. Mechanical strength such as in flexure, tension, compression, shear, toughness and hardness are common properties tested. Once the user has determined the type of strength needed, it is fairly simple to choose a board within reasonable limits.

STANDARD TESTS

Most of the tests for properties are covered by standards. The principal one, ATSM D 1037, gives procedures to determine density, static bending (flexure), tension (parallel and perpendicular to the surface), nail withdrawal, hardness, water absorption, linear expansion, and durability in exposure. Another test, ASTM D 142-52, covers shear and compression strength, and impact. Although these tests were set up to compare the differences of the woods and wood compositions, not all have the same usefulness in design. For example, direct nail-withdrawal data are useful when nails are loaded in tension. However, nails (and screws) should preferably be loaded in shear. Glueline shear, as prescribed in ASTM D 905-52, is primarily an inspection step to check adhesive joint quality.

Hardboards are too thin to hold screws in most applications so screw-holding need not be tested. Tensile strength parallel to the surface is not applicable when such boards are applied as surfacing. Here, boards are stressed either in compression or in bending. In general, tensile strength perpendicular to the surface need not be tested for hardboards because these values are the same as those parallel to the surface. Hardness of the surface is a reliable indication of resistance to surface indentation, but somewhat less reliable for wear.

MOISTURE ABSORPTION

Dimensions increase with increase in moisture content, but because the boards, especially the thicker ones, are slow to equalize in their moisture content, stability is usually judged from the change in dimensions after a 24-hr soaking in water.

One sensitive way to estimate the full effect of moisture is to subject exposed panels to mechanical property tests, then compare these data with those of the unexposed materials. In addition, such tests as boiling in water will reveal the ability of adhesive binders to withstand severe moisture conditions.

Composition boards seldom warp except where higher moisture on one side causes differential expansion. The photo on page 39 shows a special test where such moisture gradients cannot be avoided. The gradients can generally be minimized by specifying paint or some such finishing for both sides, or in sandwich composites, by facing both sides of the core with the same material.

CUTTING TO SHAPE

Although these compositions are essentially wood and can be worked with normal woodworking tools, the resin binder increases wear on tools. Cutting edges must be more frequently sharpened and carbide tools are recommended. The US Forest Products Laboratory is developing standard tests for evaluating machinability of wood compositions and until these are available it is difficult to give a standard rating—machinability must be determined empirically.

For REPRINT of above article, just check P36 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Of the three types of composition boards described in the above article, sandwich construction gets its characteristics from these three components—core, facing and the adhesive. A separate article has been devoted to each of the three sandwich components, and the series is available from our Reader Service Department as a combined reprint at 25 cents each.

Or you can consult your PRODUCT ENGINEERING file. Each article was published under the cover-all title, "Selection Guide for Sandwich Panel":

Core Materials, Jan 20 '58, p 70—compares broad spectrum of wood, mineral and foam plastics for heat and sound barriers as well as structural members.

Facing Materials, Apr 28 '58, p 80—covers metals, plastics and wood properties for use as skin materials.

Adhesives, May 26 '58, p 59—gives strength in shear, tension and peel to help determine choice of thermoplastic or thermosetting adhesive.

20 DYNAMIC APPLICATIONS FOR

SCREW THREADS

Have you forgotten how simply, and economically, screw threads can be made into dynamic members of a linkage? Here are some memory-joggers, plus suggestions for simplified nuts, threads and nut guides.

KURT RABE, *consulting engineer*
Berlin, Germany

You need a threaded shaft, a nut . . . plus some way for one of these members to rotate without translating and the other to translate without rotating. That's all. Yet these simple components can do practically all of the adjusting, setting, or locking used in design.

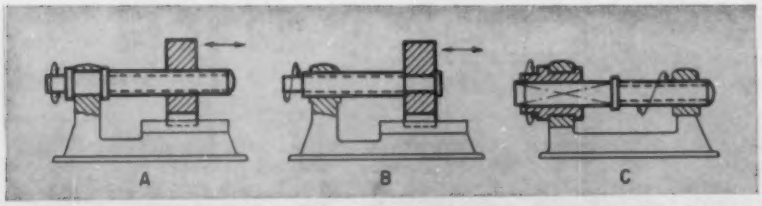
Most such applications have low-precision requirements. That's why the thread may be a coiled wire or a twisted strip; the nut may be a notched ear on a shaft or a slotted disk. Standard screws and nuts right off your supply shelves can often serve at very low cost.

Here are the basic motion transformations possible with screw threads (Fig 1):

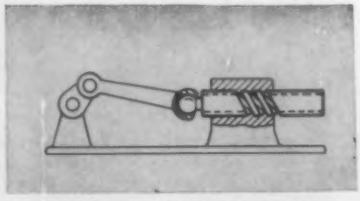
- transform rotation into linear motion or reverse (A),
- transform helical motion into linear motion or reverse (B),
- transform rotation into helical motion or reverse (C).

Of course the screw thread may be combined with other components: in a 4-bar linkage (Fig 2), or with multiple screw elements for force or motion amplification.

continued, next page



1 MOTION TRANSFORMATIONS of a screw thread include: rotation to translation (A), helical to translation (B), rotation to helical (C). Any of these is reversible if the thread is not self-locking (see screw-thread mathematics on following page—thread is reversible when efficiency is over 50%).



2 STANDARD 4-BAR LINKAGE has screw thread substituted for slider. Output is helical rather than linear.

REPRINTED—Circle P35, inside back cover

A REVIEW OF

a — friction angle, $\tan a = f$
r — mean radius of thread
$= \frac{1}{2}$ (root radius + outside radius), in inches
l — lead, thread advance in one revolution, in.
b — lead angle, $\tan b = 1/2\pi r$, deg
f — friction coefficient
P — equivalent driving force at radius r from screw axis, lb
L — axial load, lb
e — efficiency
c — half angle between thread faces, deg

SQUARE THREADS:

$$P = L \tan (b \pm a) = L \frac{(l \pm 2\pi r f)}{(2\pi r \mp fl)}$$

Where upper signs are for motion opposed in direction to L. Screw is self-locking when $b \leq a$.

$$e = \frac{\tan b}{\tan (b + a)} \quad \text{(motion opposed to } L\text{)}$$

$$e = \frac{\tan (b - a)}{\tan b} \quad \text{(motion assisted by } L\text{)}$$

V THREADS:

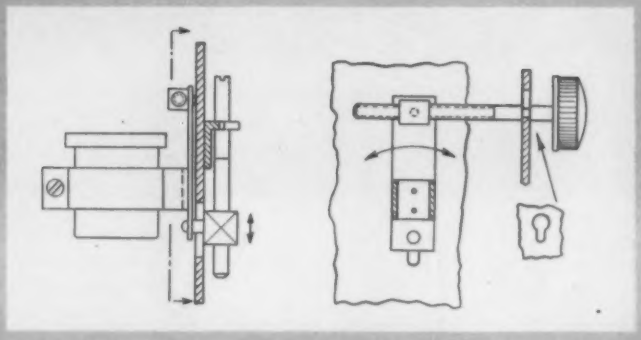
$$P = L \frac{(l \pm 2\pi r f \sec c)}{(2\pi r \mp lf \sec c)}$$

$$e = \frac{\tan b (1 - f \tan b \sec c)}{(\tan b + f \sec c)} \quad \text{(motion opposed to } L\text{)}$$

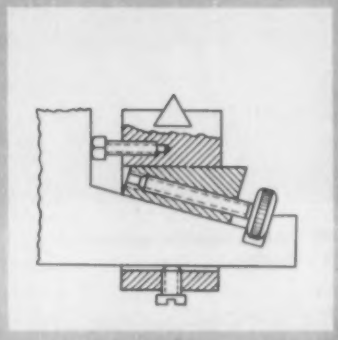
$$e = \frac{\tan b - f \sec c}{\tan b (1 + f \tan b \sec c)} \quad \text{(motion assisted by } L\text{)}$$

For more detailed analysis of screw-thread friction forces, see Marks *Mechanical Engineers' Handbook*, McGraw-Hill Book Co.

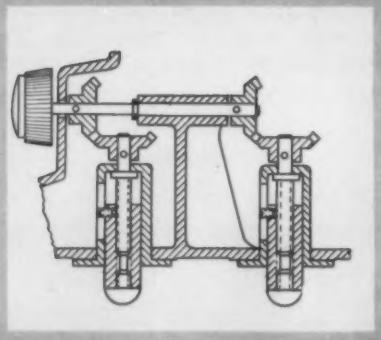
Rotation to Translation



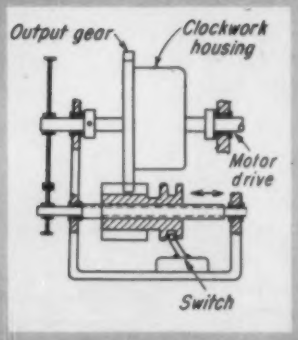
3 TWO-DIRECTIONAL LAMP ADJUSTMENT with screwdriver to move lamp up and down. Knob adjust (right) rotates lamp about pivot.



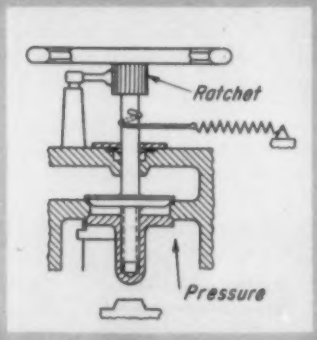
4 KNIFE-EDGE BEARING is raised or lowered by screw-driven wedge. Two additional screws locate the knife edge laterally and lock it.



5 SIDE-BY-SIDE ARRANGEMENT of tandem screw threads gives parallel rise in this height adjustment for projector.

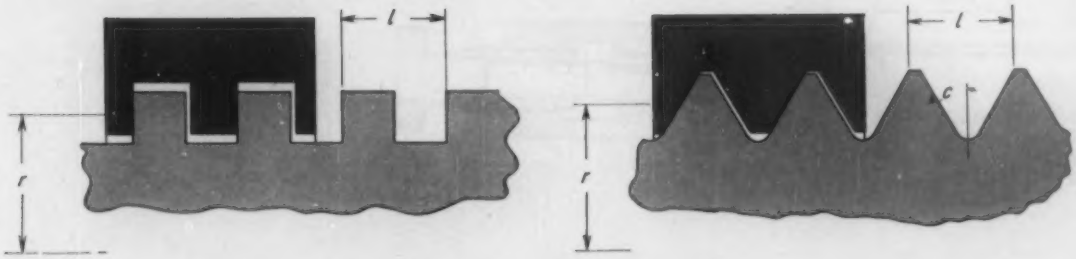


6 AUTOMATIC CLOCKWORK is kept wound tight by electric motor turned on and off by screw thread and nut. Note motor drive must be self-locking or it will permit clock to unwind as soon as switch turns off.

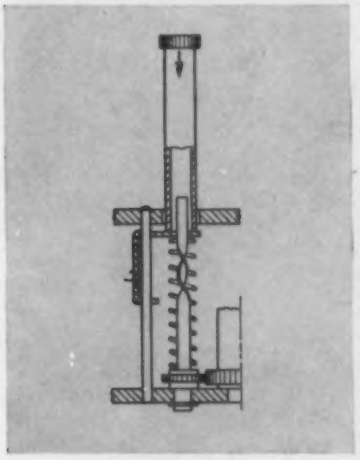


7 VALVE STEM has two oppositely moving valve cones. When opening, the upper cone moves up first, until it contacts its stop. Further turning of the valve wheel forces the lower cone out of its seat. The spring is wound up at the same time. When the ratchet is released, spring pulls both cones into their seats.

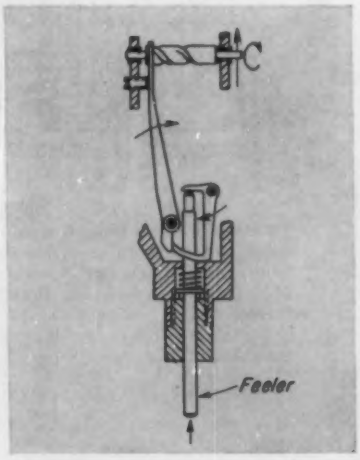
SCREW-THREAD MATHEMATICS



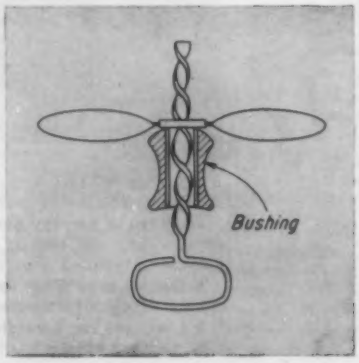
Translation to Rotation



8 A METAL STRIP or square rod may be twisted to make a long-lead thread, ideal for transforming linear into rotary motion. Here a push-button mechanism winds a camera. Note that the number of turns or dwell of output gear is easily altered by changing (or even reversing) twist of the strip.

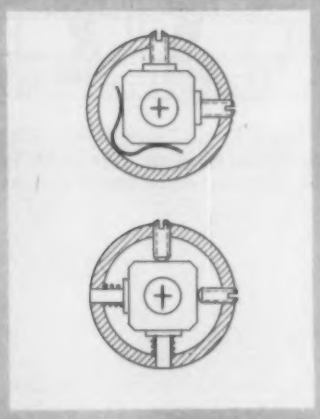


9 FEELER GAGE has its motion amplified through a double linkage and then transformed to rotation for dial indication.

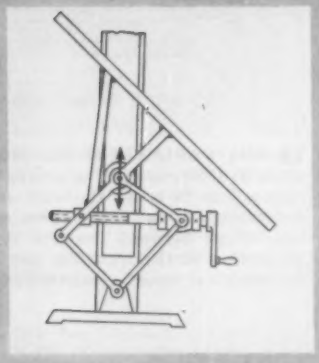


10 THE FAMILIAR flying propeller-toy is operated by pushing the bushing straight up and off the thread.

Self-Locking

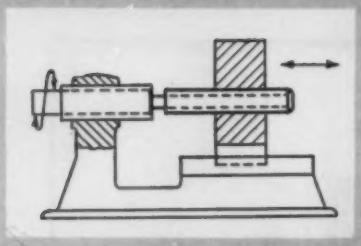


11 HAIRLINE ADJUSTMENT for a telescope, with two alternative methods of drive and spring return.

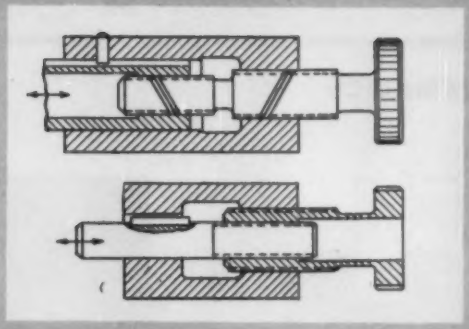


12 SCREW AND NUT provide self-locking drive for a complex linkage.

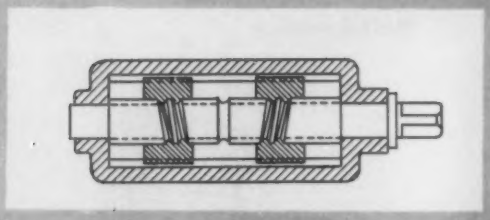
Double Threading



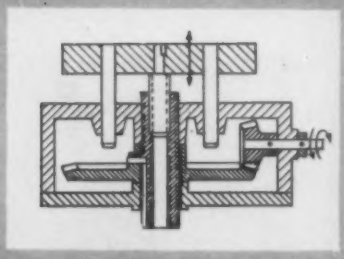
13 DOUBLE-THREADED SCREWS, when used as differentials, provide very fine adjustment for precision equipment at relatively low cost.



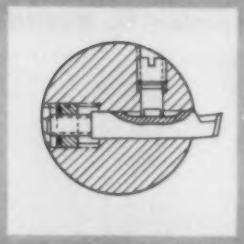
14 DIFFERENTIAL SCREWS can be made in dozens of forms. Here are two methods: above, two opposite-hand threads on a single shaft; below, same hand threads on independent shafts.



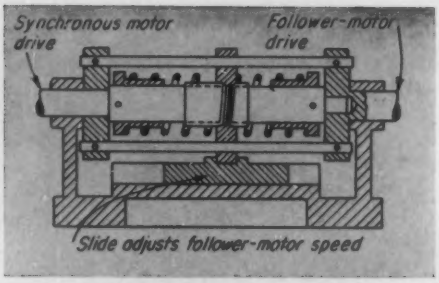
15 OPPOSITE-HAND THREADS make a high-speed centering clamp out of two moving nuts.



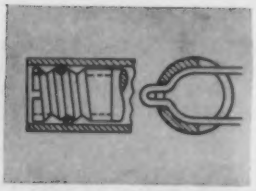
16 MEASURING TABLE rises very slowly for many turns of the input bevel gear. If the two threads are 1½—12 and ⅝—16, in the fine-thread series, table will rise approximately 0.004 in. per input-gear revolution.



17 LATHE TURNING TOOL in drill rod is adjusted by differential screw. A special double-pin wrench turns the intermediate nut, advancing the nut and retracting the threaded tool simultaneously. Tool is then clamped by setscrew.

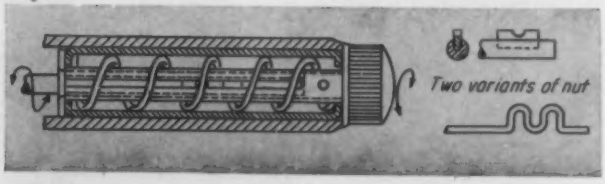


18 ANY VARIABLE-SPEED MOTOR can be made to follow a small synchronous motor by connecting them to the two shafts of this differential screw. Differences in number of revolutions between the two motors appear as motion of the traveling nut and slide so an electrical speed compensation is made.



19 (left) **A WIRE FORK** is the nut in this simple tube-and screw design.

20 (below) **A MECHANICAL PENCIL** includes a spring as the screw thread and a notched ear or a bent wire as the nut.



EDITOR'S NOTE: For other solutions to adjusting, setting, and locking problems in translating motion, see:

10 Ways to Employ Screw Mechanisms, May 26 '58, p 80. Shows applications in terms of three basic components—actuating member, threaded device, and sliding device.

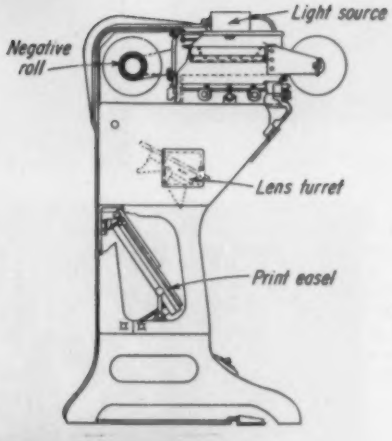
5 Cardan-gear Mechanisms. Sep 28 '59, p 66. Gearing arrangements that convert rotation into straight-line motion.

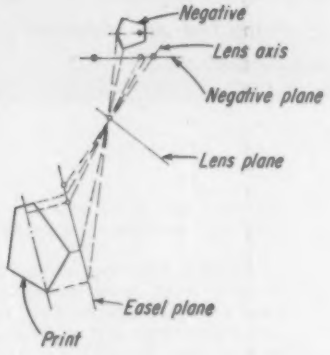
5 Linkages for Straight-line Motion, Oct 12 '59, p 86. Linkages that convert rotation into straight-line motion.

For **REPRINT** of above article, just check P35 on one of the **Reader Service** cards bound in this issue.

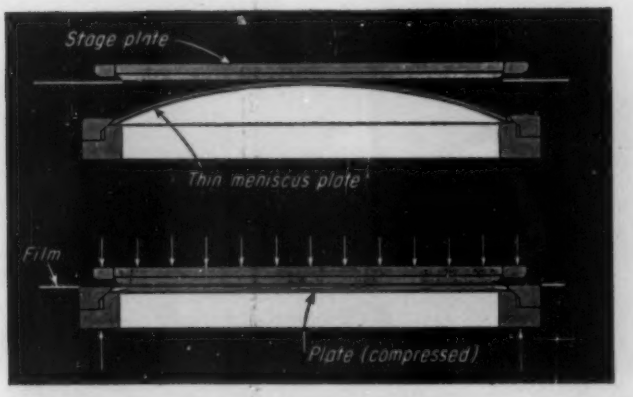
Thin Glass Plates Sharpen Aerial Photos

The thick glass that holds negatives and paper in an aerial-photograph printer causes astigmatism. Substituting thin meniscus-shaped pressure plates is the answer here. Resolution of 20 lines per mm becomes possible on this transforming printer, even in corners of 9-by-9 negatives.





PRINTER PRODUCES PHOTOS from rolled negative used in aerial cameras. Negative rolls, cold-light source, and pressure plates are mounted on light-tight housing that rotates to align negative. Turret-mounted lenses provide two magnification ratios—0.87:1 and 1:1. The 79° angle between negative and easel planes corrects for a camera tilt of 20°.

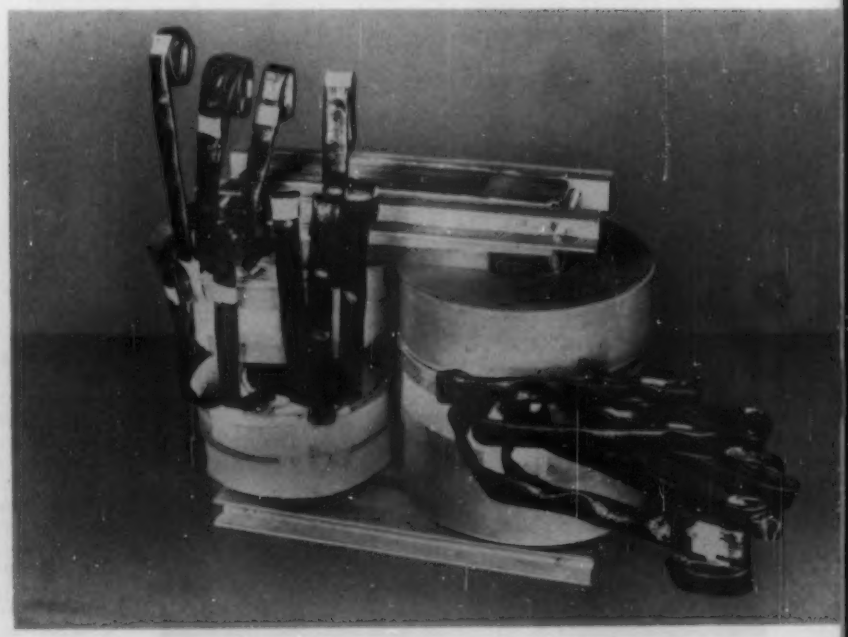


HIGH-RESOLUTION PRINTS, a must for aerial mapping, require a printer with a flat-field, wide-angle lens. However, thick plates, commonly used to hold the negatives and printing paper in place during exposure, create serious astigmatism problems because refraction is not uniform at all points. Thin, flat plates tend to warp when pressure is applied, so thin, meniscus-shaped ones were substituted. Pressure that they exert holds the negatives and paper in place. Since these plates are only 1/16 in. thick, compared with ⅝ in. in existing comparable printers, astigmatism is sharply reduced. Stage plate, behind negative or print, is thick by comparison and its flatness unaffected by the moderate pressure involved.

PS . . . Aerial-photo maps are made from a composite of several pictures taken at the same time. One camera shoots almost straight down; others aimed at a fixed angle simultaneously photo the surrounding area. This printer rectifies the oblique exposures so they appear as if taken from directly overhead. The transformed obliques are then combined with the center vertical print into a composite with extremely wide angular coverage. Dual-range transforming printer Model 060 is produced by the J W Fecker Division of the American Optical Co, Pittsburgh.

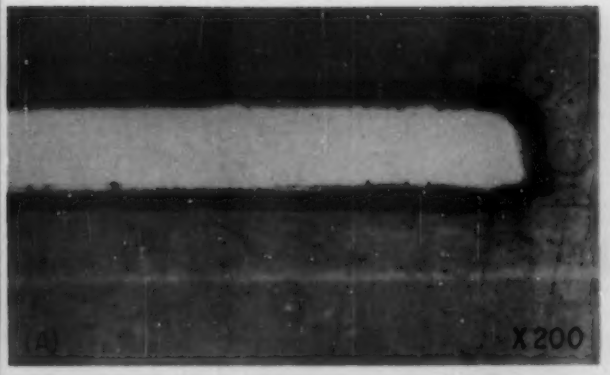
Welder Lightened by Aluminum Transformer

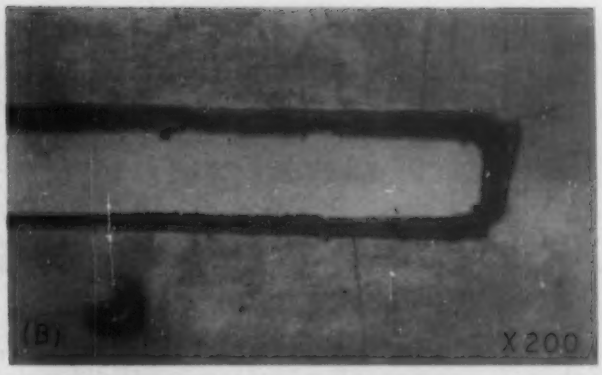
The aluminum foil windings are self-insulated by oxide coating, which also eliminates high-temperature problems. Though thin, the insulating film can withstand more heat than the conductor.

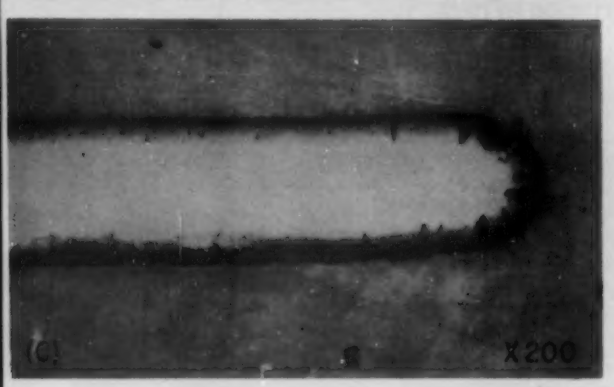


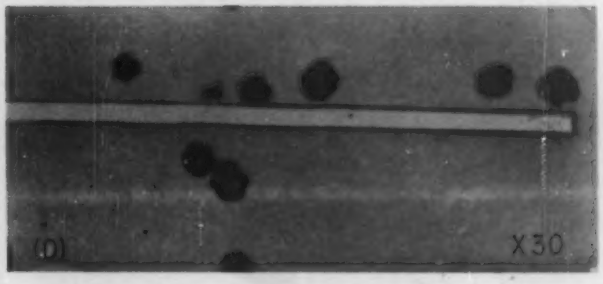
AUTOMATICALLY WOUND COILS have porcelain formers designed to stand the 500-C temperatures permissible in oxide-insulated aluminum windings. Asbestos was previously used but its silicone-varnish impregnant failed to stand up to such temperatures. Dual voltage taps enable the unit to weld stainless steel, cast iron and mild steel. Safety features include glass sleeve to insulate leads, non-arcing roller switch, fiberglass outer casing and totally insulated electrode holder. Formers are shaped to provide air circulation by convection.

PS . . . Aluminum anodized by the sulphuric acid process produces a self-insulating film. Its inner layer is a very thin, continuous film; the porous outer layer is much thicker. Coils of the anodized foil or strip can function at 500 C without deterioration of the film. Rated at 175 amps continuous duty, the welder weighs 67 lb, draws 40 amps from 220-v line. It was developed by Ashton-Young Engineering Development Co Ltd, Surrey, Eng. Anodizing process is by Tyne Chemical Co Ltd, Durham, Eng.



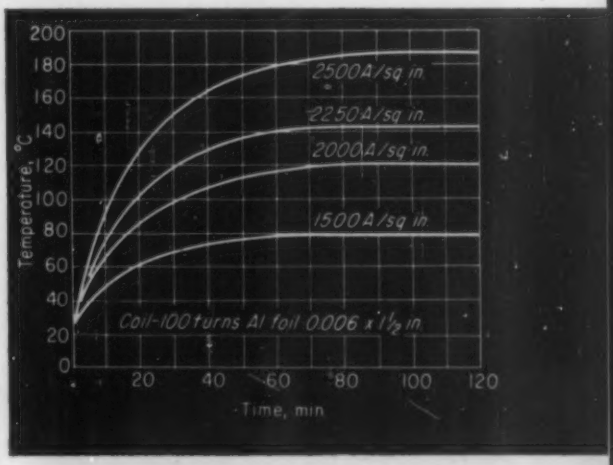






OXIDE-FILM CONTINUITY on foil—important for uniform insulation, especially at the edges—depends on edge contour and anodizing processes. Rounded foil edges without burrs or sharp points are preferred, but satisfactory film continuity is possible even when the edge is not smoothly rounded (A and B). Foil shown is 0.075 mm thick with an oxide film approximately 25 microns thick. Average insulation-breakdown values for foil in (A) and (B) are approximately 403 and 303 volts rms, respectively. Round edge (C) produces better breakdown characteristics: 422 volts rms.

Anodic film thickness can be increased towards the edges to give higher electric strength there. Film on 0.075-in. foil (D) is 0.001 thick at edges and decreases to 0.0003 at center. Material so treated resists breakdown up to 342 volts rms at the center and 403 volts rms at edges.

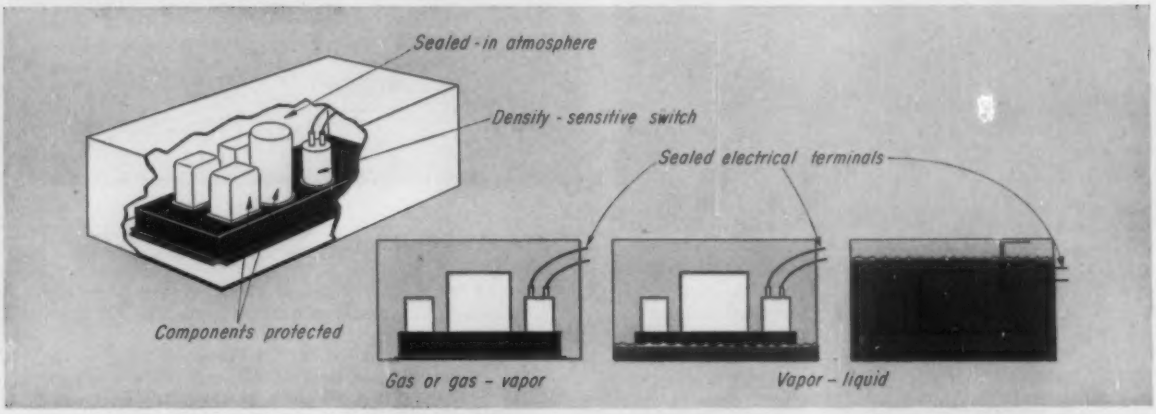


OXIDE-INSULATED COIL made of 100 turns of aluminum foil, 0.006 in. thick and 1½ in. wide, was used to check current densities. Plotted data show that, despite higher specific resistance of aluminum conductors, small cross-sectional areas with high current densities and high operating temperatures are feasible with anodic insulation. Apart from the increased thermal capacity and insulation, heat-transfer characteristics of the oxide-insulated coils are excellent. Working-temperature limits are set by the melting point of the conductor, 659 C, because the melting point of the oxide insulating film is more than 2000 C.

these vapor–liquid phases . . .

when designing SEALED-IN ATMOSPHERES

Must your product be protected by a sealed-in atmosphere? If so, there is a choice of five basic types. Here's a description of each, together with its advantages and disadvantages, and a monitoring method.



A Woman's Place in Engineering

The author, Beatrice Alice Hicks, was the first woman engineer ever hired by Western Electric Company. She holds degrees in chemical engineering and physics, has spent several years in research at Newark College of Engineering. She was chief engineer and is now president of Newark Controls Company, which makes environmental sensing devices.

Her article analyzes the basic design problems faced by an engineer who must surround his product with an artificial atmosphere of any type. Little is said about actual devices, fluids, enclosures—such information is readily available in catalogs from many companies.

B A HICKS, *president*
Newark Controls Co, Bloomfield, NJ

The simplest, lightest and cheapest sealed-in atmosphere is air. For airborne equipment simply seal clean, dry, ground-pressure atmosphere into the package during production. Ground-level air density will then be maintained at any elevation because the volume and weight of air are fixed.

But there are other atmospheres that will do the job, better in some cases, not as good in others. The various systems can be broken down into five types. Two of them—gas and the gas–vapor type—follow the ideal-gas laws for fixed volume, where pressure varies linearly with temperature:

GAS

Air—itself a mixture of gases—is the most common example of a gas atmosphere. But for better heat dissipation and protection against electrical arc-over, gases such as

THE FIVE BASIC TYPES OF SEALED-IN ATMOSPHERES

	Gas	Gas-Vapor	Gas-Vapor-Liquid		Vapor-Liquid	Liquid (experimental only)
			small liquid pool	large liquid volume		
Description	not liquefied in temperature range used		vapors are saturated in operating-temp. range			pressures kept above saturation at all temp.
			gas–vapor atmos.	liquid-immersed	all gases removed	
Typical fill materials	air; nitrogen; sulfur hexafluoride, SF_6 (Allied Chemical and Dye Corp); octafluorocyclobutane, C_4F_8 (DuPont, Freon C-318)					
		perfluorocyclicether, $C_9F_{16}O$ (Minnesota Mining and Mfg Co, FC-75); heptacosafluorotributylamine, $(C_4F_9)_3N$ (3M Co, FC-43); several Freon types (DuPont) and Genetron types (Allied Chemical and Dye Corp)				
Typical Applications	sealed electronic equipment, non-airborne					
	sealed airborne electronic equipment; power transformers; switchgear					
	X-ray units; pressurized power cables; waveguides; coaxial cables	X-ray units				

MANY MORE VARIETIES of fluorochemicals are available, but those shown are typical. The chemical symbols—greatly simplified—merely indicate total number of atoms of each element. Only the symbol for sulfur hexafluoride is exact: 1 atom sulfur, 6 atoms fluorine, directly combined as implied.

nitrogen, sulfur hexafluoride or octofluorocyclobutane can likewise be sealed into the equipment.

GAS–VAPOR

Vapor, if not too close to the liquid phase, behaves as a gas. The material to be vaporized is added in the liquid state, but remains condensed only at low temperatures. Above those temperatures it is completely evaporated, and vapor density can go no higher than what it was at the temperature of total evaporation. Although the pressure continues to increase with temperature, the increase is linear and much lower than that for a saturated vapor. One problem with this system is that the amount of liquid added must be carefully controlled.

The three other types of sealed-in atmospheres—described in the following paragraphs—do not follow the ideal-gas laws. Those containing vapor with small or large amounts of liquid will experience more-than-linear pressure increases with temperature because the liquid evaporates, increasing the density of the vapor (see "Tips for Designing," p 53). The last of these three types—liquid alone—is kept at a high enough pressure to prevent evaporation, and behaves as liquid. For any of the three, stronger enclosures are needed to contain the higher pressures that are experienced.

GAS–VAPOR–LIQUID

small liquid pool

Here the equipment is surrounded by gas and vapor only. The liquid is included merely to keep the vapor saturated. Manufacturing such a system is relatively easy, because there is a wide tolerance on the amount of liquid needed, as long as there is enough to keep the vapor saturated at the maximum temperature. The gas is added last in a simple operation. It raises density level at low temperatures where vapor density is low, and contributes its own properties to the mixture.

large liquid volume

In this type of gas–vapor–liquid system, the liquid predominates, completely surrounding the equipment. The liquid itself acts as the dielectric and heat conductor. Though substantially better than a gas, the system is relatively heavy, and orientation of the package is important—tilting is not always allowable.

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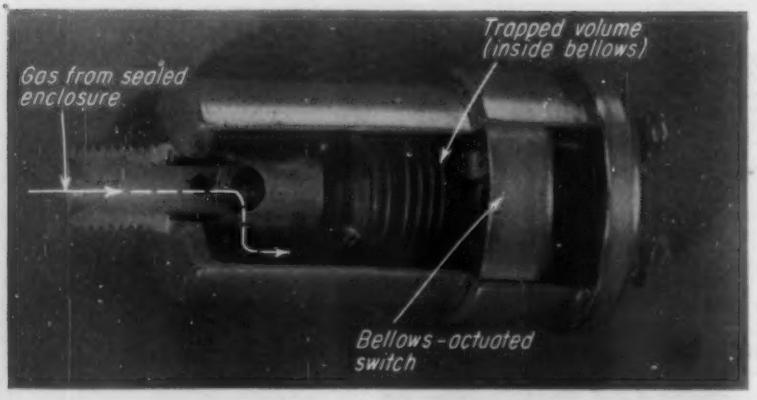


DENSITY SWITCH shown in cutaway is different from a simple pressure switch for monitoring a sealed-in atmosphere in that it automatically compensates for temperature changes. The trapped reference-volume of gas in the sealed bellows experiences the same pressure increase with temperature as the main gas volume in the enclosure. A leak or other disturbance in the main volume operates the switch. The device can be mounted inside or outside the enclosure; a battery-light or buzzer circuit connected across the switch terminals will give the necessary indication.

VAPOR–LIQUID

Best where vaporization is needed to absorb heat from hot points. If gases were present they would tend to reduce transfer of heat from the vapor to the container walls. One disadvantage: costs are increased by need to remove residual gases such as air from the container, and leave space for normal expansion of the liquid.

LIQUID

Completely sealed liquid systems under pressure are being investigated by several groups at this time. Design problems are complicated by the normal expansion of the liquid with temperature. No such systems are known to be in practical operation.

All of these systems have advantages over solid dielectrics because they are self-healing after arc-over (if the cause of the arc—such as a spurious transient voltage peak—is removed), and are not subject to permanent dielectric breakdown.

CHOOSING FILL MATERIALS

For any given gas or vapor, the greater its density the greater will be its heat conduction and the higher the potential gradient that may be tolerated without electrical arc-over. For many applications, dry air or simple gases such as nitrogen at sea-level densities (14.7 psia, 75 F) are adequate. Increasing density improves protection.

Certain gases containing fluorine (see tables) are better than air or nitrogen for arc resistance because their molecules are substantially larger, and they are electronegative, performing better in high voltage-gradients than the simple gases. These fluorine-based gases are also better for heat conduction. Vapor pressures affect the density of each type. Sulfur hexafluoride (SF_6) decomposes where there is continuous arcing, so it is not recommended for vibrators, choppers and the like.

MONITORING SEALED-IN ATMOSPHERES

Density, not pressure or temperature, is the important variable in a sealed-in atmosphere, because it determines arc resistance and heat transfer. Because of temperature variations, the enclosure pressure is not constant; and density of the sealed-in gas or vapor cannot be monitored by a simple pressure switch. Special density-sensitive switches—photo above—are needed.

In gaseous atmospheres the number of molecules present is constant over the whole temperature range so pressure increases linearly with temperature up to about 4 or 6 atmospheres. The gas-density switch can be calibrated to protect through the whole temperature range.

In atmospheres containing vapor and liquid, on the other hand, the density does not remain constant over

PRESSURES FOR TYPICAL SEALED ATMOSPHERES

Atmosphere	Temperature, °F	Pressure, psia
octafluorocyclobutane, C_4F_8 (vapor–liquid only)	0	8.8
	70	40.1
	150	140
perfluorocyclicether, $C_5F_{10}O$ (vapor–liquid only)	0	0
	70	0.6
	150	4.5
	275	35.4
(vapor–liquid, with about 0.0037 lb mols per cu ft of air or nitrogen)	−80	15
	0	18.2
	70	21.7
	150	28.3
	200	37.5
heptacosafluorotributylamine, $(C_4F_9)_3N$ (vapor–liquid only)	0	0
	70	0.02
	150	0.15
	275	3.95

VAPOR PRESSURE is a logarithmic function of temperature when there is accompanying liquid. Gas or vapor without liquid tends to obey perfect-gas laws; response is linear. Total pressure is always sum of partial pressures of all vapors and gases. Gas–vapor–liquid example is for negligible gas solubility. Only part of the useful temperature range is shown—fluids and vapors are available from −80 to over 400 F.

the temperature range—more molecules are evaporated as temperature rises. However, density can be predicted empirically or by calculation, because it has a specific value at each temperature. The gas-density switch must be set at one of the known conditions, giving accurate protection at or near that point.

For stability, these switches are designed to give warning at one density, but to "reset" at a different density when the leak has been repaired. For example, the warning might come when the enclosure has a pressure of 19 psia, but reset would not occur until the enclosure was pumped back up to 21 psia at the same temperature. This will prevent transient "fluttering" of the switch. Such a switch could actuate an alarm for leakage and also indicate when the package has been filled to the correct density.

Here are two examples of product designs that use density-sensitive switches to monitor a sealed-in atmosphere:

- The antenna couplers on the Boeing 707 and Hustler B-58 handle very high voltages and would arc-over in the upper atmospheres. Therefore, they are designed to be filled and hermetically sealed with nitrogen at about 20 psia at 75 F. A gas-density switch mounted in each antenna coupler indicates remotely at the pilot's panel board.

- Fire extinguishers—hermetic enclosures of a special type—are sometimes discharged in remote locations. An integrated control system shows which units are ready for recharging.

TIPS FOR DESIGNING

Gases and vapors are lightest and cheapest. If the liquid part of the sealed-in atmosphere predominates, weight and cost increase.

Tilting the equipment during operation is permitted only if the sealed-in atmosphere is fairly homogeneous—all gaseous or all liquid. Otherwise you risk overheating or arcing if parts are exposed when the container tips.

Arc suppression theoretically is best in a vacuum. It decreases substantially in the presence of small amounts of gas or vapor; but it increases again as gas density rises further. During this stage, resistance increases linearly with density. The number of molecules, not the pressure or temperature, determines arc-over resistance; so even at low temperatures you must take care to provide a suitable gas density. Sometimes preheaters are used to raise the vapor density.

Heat dissipation in vapor-liquid atmospheres can be more rapid than in gas, liquid or vapor atmospheres alone. Because of its latent heat of vaporization, the liquid quickly absorbs large amounts of heat from the hot spots, transferring it later by condensation on the surface of a heat exchanger or the walls of the container. But you must be careful that bubbles of evaporated liquid don't cross arcing points and lessen resistance to arc-over.

Cooling is also helped by fact that vapor densities increase with temperature, improving heat dissipation when it is needed most.

Natural cooling of the external walls of any container is best when the surface area is large in proportion to the volume being cooled.

Pressure-temperature characteristics of sealed gases and vapors—without liquids—tend to obey the ideal-gas laws within the range of conditions found in typical enclosures (−85 to 400 F). This relationship applies:

$$P = 10.7 \times D_M \times T$$

where P is pressure, psia; D_M is gas or vapor molal density, lbs per cu ft divided by molecular weight; and T is temperature in degrees Rankine. For these units the ideal-gas constant is 10.7.

Pressure-temperature characteristics of gas-vapor-liquid mixtures are complex but permit control of "charge pressure" by choosing suitable proportions of gas and vapor. Pressure rise with temperature is greater for a vapor–liquid or a gas–vapor–liquid mixture than for a gas or a vapor that has no accompanying liquid. The principal reason is that a liquid gives off additional vapor as temperature is increased—raising the vapor density.

The gases used are inert, and their partial pressures are independent of those for the vapor in the sealed-in atmosphere. However, if a gas is soluble in the liquid at the operating conditions, its partial pressure will not necessarily obey the ideal-gas law. The dissolved gas tends to be driven out of solution by higher temperatures, but is also absorbed because of the increased pressures. Usually, the gas partial-pressure increase with temperature tends to be at a greater-than-linear rate; but actual test data should be obtained for each design.

Leakage—whether through joints or by diffusion—depends on the size of the molecules as well as the pressure differential. Greatest leakage occurs when molecules are small and pressures high. Any material can pass molecules. Plastics and synthetics do so relatively easily. Metals are more resistant but not invulnerable. Glass and glazed ceramics are reliable, but their joints are vulnerable.

Maintenance—particularly checking and refilling—is best handled by trained personnel in service shops. The initial design can provide for visual or remote monitoring by including a trapped-volume-type density-measuring switch that detects leakage during storage or service.

EDITOR'S NOTE: Environmental protection of equipment with sealed enclosures has been covered in these previous articles:

Encapsulated Relays, Mid-Oct '57, p I-2, shows how keeping contacts under glass eliminates contact oxidation.

Motor Enclosures for Contaminated Atmospheres, Oct 14 '57, p 106, describes ways to cool and seal a motor without allowing contamination to enter from the outside.

New Foamed Silicones Give Hi-temp Insulation, Jan 5 '59, p 50, summarizes insulating properties up to 650 F, shows how silicones can be foamed around electronic components.

Tips for dissipating heat from any product—including sealed enclosures—are found in these articles:

When Air is the Coolant, Feb 16 '59, p 54, shows how to determine if self-cooling of a product by radiation or convection will be sufficient, and how to estimate the amount of forced convection that might be needed.

Removing Heat from Electronic Devices, July '54, p 124, includes tables of temperature difference vs required cooling area . . . and explains effect of color on heat radiation.

Many variations of sealed ballbearings are now standard—but no one type can satisfy all possible operating conditions. Selection usually means finding the best compromise. The author discusses seal types, materials and test methods, and rates the seal types in order of preference under various conditions.

which type of

INTEGRALLY SEALED BALLBEARING?

WAYNE W GORDON, *product engineer*
The Fafnir Bearing Company, New Britain, Conn

Most ballbearings can be ordered with built-in seals to retain a grease (usually for the life of the bearing), and to keep out foreign material. Although there are three basic types of these integral seals, many variations are possible and no one design has proved sufficiently versatile to handle all applications. Each seal configuration has its advantages and limitations, and each must be selected with care. The 12 most popular integral-seal designs are discussed here along with a selection guide to the best type for the operating conditions under consideration.

A RUNDOWN ON THE BENEFITS

Integral seals not only retain lubricant and act as shield against foreign material; they often eliminate need for supplementary bearing seals. This saves design space and their compact design permits easy assembly as only one part. Integral seals also enable bearings to be prelubricated with a high-quality, long-life, factory-approved lubricant and sealed on both sides so that the bearings will require no further lubricant for the life of the bearing. This prevents premature bearing failure caused by dirt in the grease, and the danger of overlubrication or underlubrication—either could cause the bearing to overheat and fail prematurely.

Exhaustive laboratory testing to qualify greases for prelubricated bearings includes tests for storage separation (or bleeding), oil evaporation at elevated temperatures, oxidation resistance (storage life), dirt count, consistency, melting point, low-temperature resistance, corrosion (no excess acid or free alkali), water resistance, torque tests for mechanical stability, and tests for compatibility with other materials such as bronze cages or seal materials when used.

Because prelubricated bearings need not be relubricated under normal conditions, reduced maintenance costs result and there is no need for grease fittings and grease guns. However, if conditions are severe or bearing operating temperatures are in excess of 180 F (normal temperatures are −20 to 180 F), periodic relubrication may be advisable.

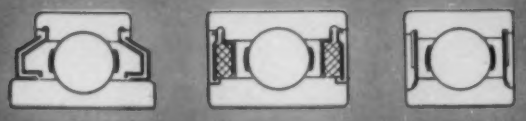
If operating temperatures are higher than approximately 250 F, special high-temperature greases will be required. Also, bearings may need a special internal fit-up, special seal materials, or have to be heat-stabilized for growth.

BASIC SEAL TYPES

There are three basic types of integral-sealed ballbearings: labyrinth, contact and felt (illustrated above). Although the felt seal is treated here as a separate type it is actually the earliest contact type, and is best referred to as a light contact-type seal. Felt seals are frequently combined with labyrinth seals for increased effectiveness.

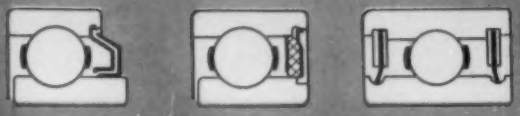
INTEGRAL-SEAL BEARINGS

Three Basic Types...



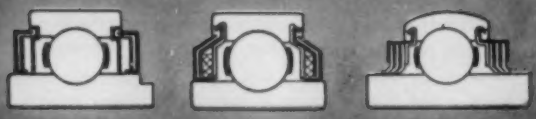
1. Labyrinth 2. Felt 3. Contact

And 9 Popular Variations.



(a) Single Labyrinth (d) Single Felt (g) Double-contact, wide width

(b) Shield and Labyrinth (e) Shield and Felt (h) Double-contact, narrow width



(c) Double Three-piece Labyrinth (f) Double Felt-labyrinth (i) Double, triple-lip contact

Selection Guide to INTEGRAL-SEAL BALLBEARINGS

(Ratings 1, 2, 3 are in order of preference)

Operating Conditions	Contact-Seal Type	Labyrinth-Seal Type	Felt-Seal Type	Comments
Dirt and abrasives; Dusty atmospheres	1	3	2	Contact type generally preferred because it is a positive friction seal. Special contact-seal constructions available for extremely severe conditions.
Concentrated vapor and liquids	1	3	2	Contact type generally preferred.
High speeds	3	1	2	Labyrinth type most efficient at high speeds. No heat generated at seal because seal is frictionless.
Low and moderate speeds	1	3	2	Contact and felt types are preferred, particularly when conditions are severe. Some contact-seal constructions can take speeds as high as 12,000 rpm (for basic 205-size bearing).
High temperatures	2	1	3	Special contact-seal materials and specially heat-treated felts available for operation at temperatures above 200 F. High-temperature lubricants required. Above 250 F., special constructions or bearing materials may be required.
Low temperatures	2	1	3	Special lubricants may be required below —20 F. Special contact seals required below —70 F.
Grease retention	1	3	2	Grease loss negligible and not a consideration for most applications. Contact type preferred for especially critical applications such as food-processing machinery.
Low torque	3	1	2	All three types have negligible starting and running (friction) torques — except for special contact-seal constructions designed for max. sealing effectiveness.
Minimum width	1	2	3	Some contact types available in single-row, open-type widths. Labyrinth types require wide inner ring. Felt seals generally require wide inner and outer rings.

Selection of a specific seal type, or the best seal combination to be used, should be based on knowledge of the characteristics, advantages, and limitations of the various seal configurations and seal materials.

Labyrinth-seal Types

The labyrinth seal is frictionless. It consists of two steel members assembled in the bearing with a close running clearance. The inner member is fixed in a groove in the outer ring and has a close running clearance with the outer seal member and OD of the inner ring. The outer member is pressed on the OD of the inner ring and rotates as an external slinger.

The slinger action keeps contaminants out and the slight grease purging between the inner and outer seal plates increases effectiveness by acting as a supplementary grease seal. The efficiency of such construction is dependent on close running clearances: precision manufacturing has to hold close tolerances of the parts and assembly.

Labyrinth seals are mainly found in high-speed and high-temperature applications. They can be operated at speeds comparable to sealless bearings and are most efficient at high speeds because they do not generate heat. They also can endure high ambient heat because the seal members are steel (at temperatures above 180 F a high-temperature grease may be required). The ballbearings here have a large grease reservoir and standard-width outer rings.

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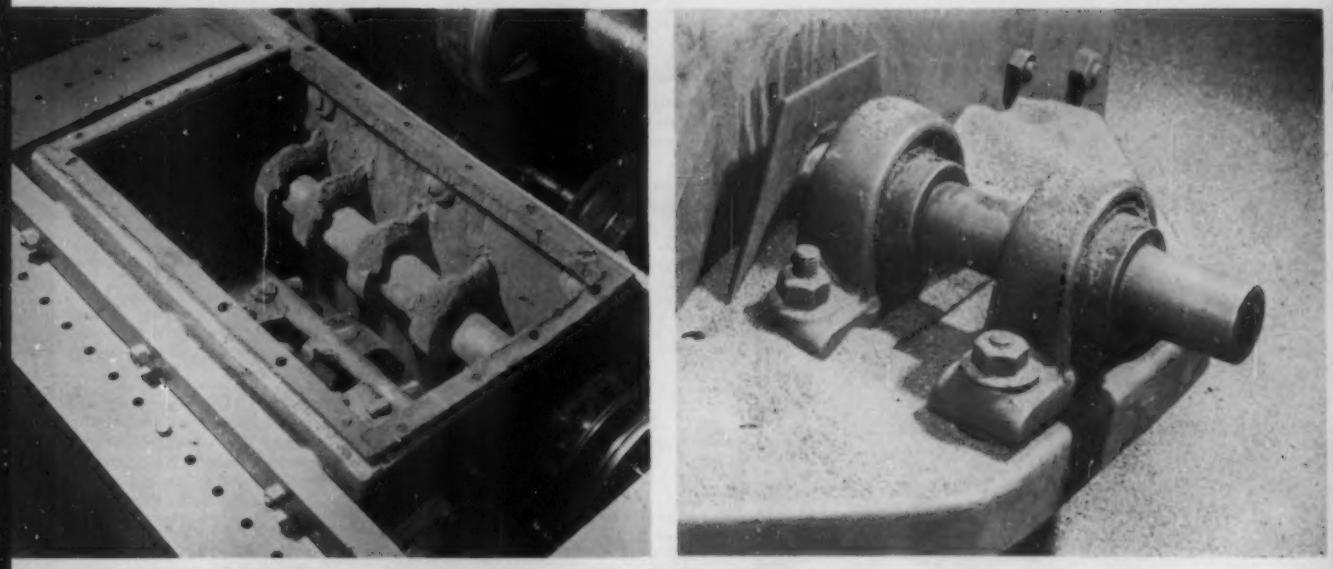


LABORATORY TEST in "dust box" leads to more effective seal types for pillow-block bearing (right) on sandblasting machine.

Chief limitations of labyrinth seals are: they are not as effective as contact seals at slow speeds when dirt conditions are severe, and they are not effective against vapors or liquids.

They are most commonly used in high-speed motors, portable tools, blowers, domestic appliances, textile machinery and other high-speed applications.

Light-contact (Felt) Types

Two general types of felt seals are common: the contact type—a cap assembly made of two pressed-steel plates enclosing an oil-impregnated felt washer, and a contact-labyrinth combination. The latter is essentially same construction as the former, but with a steel slinger pressed on the bearing's inner ring, outboard and felt-cap assembly. The felt washer rides on the ground OD of the bearing inner ring, or on the lip of a slinger with a light contact, and prevents entry of foreign matter into the bearing by absorbing and trapping the contaminants.

Felt seals are suitable for moderate and fairly high speeds because the lubricant is wicked by capillary action and the seal has a low coefficient of friction. Such seals can take speeds up to 4000 ft per min., and possibly higher. Their sealing ability is chiefly dependent on basic felt construction and the size, shape, density (oil-absorption characteristics) and resiliency of the felt washer.

Felt seals require wide-width bearings and are generally ineffective in severely dusty and dirty applications such as encountered in agricultural and many industrial applications—particularly if the operating speeds are low or moderate. Also, plain felt seals are generally ineffective against liquids—although laminated felt seals consisting of plain felt washers laminated with thin, oil-resistant synthetic rubber can do a better job.

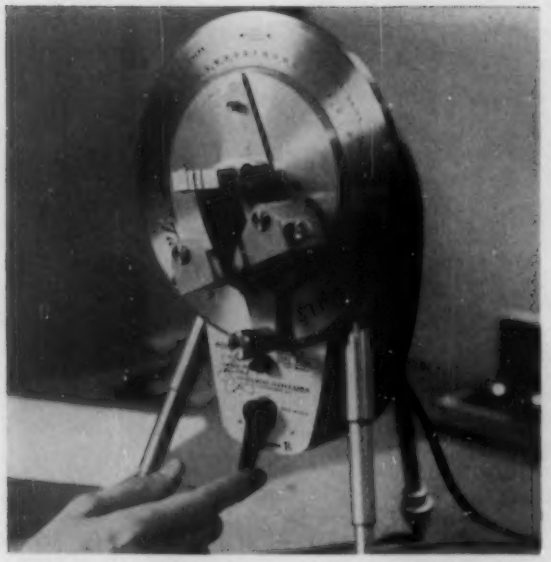
Most-suitable applications are found in vacuum cleaners, small fractional-hp motors, and pneumatic tools.

Contact (Flareout) Types

These are positive friction-type seals. The sealing washer, usually a thin, flexible synthetic-rubber material, is held in place by one or more steel retaining-washers or caps. The seals are fixed in an outer-ring seal groove and wipe on the ground surface of the inner ring or the inner ring seal rabbet. A friction interference between the seal bore and the inner ring assures positive pressure even under conditions severe enough to cause size-change or wear at outer edge of the seal lip. Because it resists pressure from dirt, the flareout design gives maximum sealing effectiveness. It also permits some grease purging if necessary. Most commonly, this type has one seal on each side of the bearing. But where severe abrasive conditions exist, such as met in many agricultural applications, as many as three seals may be required on each side.

Contact seals are best for low or moderate speeds, although certain types, such as the wide-width contact illustrated on previous page, take fairly high speeds. For example, a basic 205 bearing size (25-mm bore) with this type of seal construction can be operated at 12,000 rpm. As the limiting speeds are based on surface speed at the seal lip, smaller bearing sizes can be run faster, while slower speeds are recommended for larger sizes. However, multiple seal constructions, such as the triple-lip contact, should be restricted to slow and moderate speeds because of heat generated from seal friction.

Because of friction, contact seals have slightly higher starting and running torques—but the torque values are low and are considered negligible for most applications. The increased torque for the triple-lip sealed bearing does develop heat at high speeds, therefore triple-seal bearings are recommended for operation at only slow and moderate speeds—although basic 210 size (50-mm bore) bearings have been run successfully at speeds as high as 800 rpm. As a



STIFFNESS TESTER measures resilience of seal materials by applying specified torque to a cantilever-mounted strip of material, and noting the deflection.

general rule, heat must be expected at speeds in excess of 800 rpm. This heat may not be detrimental to the bearing itself but must be tolerable in the application.

Contact-seal bearings are available in various constructions. Some types are interchangeable with open-type, non-seal bearings. Applications include: aircraft pulleys and rod ends, electric motors, pumps, heating and air-conditioning units, industrial and agricultural machinery.

CONTACT-SEAL MATERIALS

Felt . . .

for light-contact seals, is commonly called "wool" felt and should not be confused with synthetically bonded or other materials of feltlike appearance that have different constructions and properties. Felt has good oil-absorption properties and abrasion resistance, but a tendency to glaze at high speeds. Most felt seals are suitable for operation up to 250 F. At higher temperature, glazing and charring may occur and specially treated felt, or felt impregnated with high-temperature fluids, should be used.

Buna N (nitrile) rubber . . .

is the standard material for flareout type of contact seal. It is compatible with most greases, has good abrasion resistance, resists most common chemicals and solvents, and has good aging characteristics—so adds up to the best general-purpose seal to date. This material is preferred over other common synthetic rubbers such as neoprene because it resists such high-temperature diester-type lubricants as those used in the −67 to 250 F temperature range (military specification MIL-G-3278A). The Buna N seal becomes stiff and brittle above 250 F if exposed for long periods, but will remain an effective seal if it is not removed from the bearing. It may be used at temperatures up to 300 F for short periods. Where a greater resistance to dirt pressure is desirable, such as in agricultural applications, a stiffer form of Buna N seal is used.

Hycar PA (polyacrylic) . . .

coated on Dacron fabric has properties similar to the Buna N except that it can take higher temperatures (up to 350 F or so). However, it has relatively poor resistance to alkalis, acids, and aromatic and aliphatic solvents.

Teflon-coated glass fabric . . .

is one of the most successful "specialty" seal materials. Although inert to nearly all chemicals and useful at temperatures in the −125 to 500 F range and as high as 600 F for short periods, this material is relatively stiff and cannot be made into an extreme flareout configuration. Also, toxic vapors are given off above 400 F. However, this is generally not a problem if the room is well ventilated.

Other "specialty" materials, for unusual applications, are:

Nylon has excellent resistance to some fluids and chemicals such as "Skydrol", caustic soda, and others.

Silicones have a temperature range from −100 to 450 F.

Fluoro-elastomers, such as "Viton A", and "Fluorel" have good high-temperature characteristics to 450 F and higher. Recent reports indicate that Viton A also has good radiation resistance at high temperatures.

LS-53 fluoro-silicone has the wide temperature range of silicones, and good fuel resistance.

Variations of Teflon such as Teflon on Teflon cloth show some promise as specialty seal materials, but fabrication from sheet form for seals is difficult and costly.

TESTING THE SEALS

Static tests of contact seal materials determine grease and oil compatibility, chemical resistance, temperature characteristics, flexibility, resiliency, and tear strength.

In addition, sealed bearings are run in laboratory dust boxes under extremely severe conditions to determine the relative effectiveness of different seal constructions. In one test, bearings are operated within a suspension of finely divided cement dust caused by paddles continuously rotating and throwing the dust up against the seals. In another test, sealed bearings are run completely submerged in fine emery dust to simulate severe conditions such as those encountered in agricultural disk harrows. Sealed bearings are also subjected to motor spin tests to assure that torques of contact-seal bearings are controlled and proper running clearances are maintained for labyrinth-seal bearings.

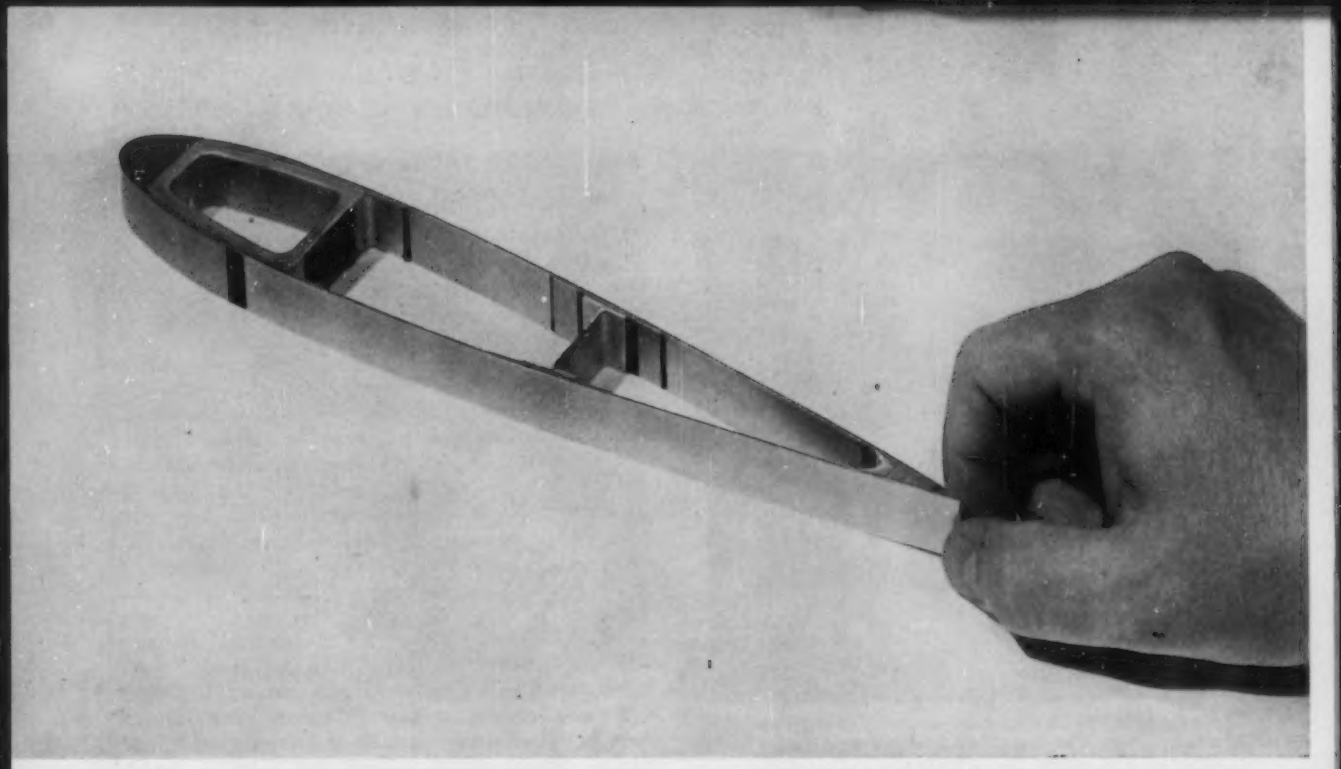
For REPRINT of above article, just check P34 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For information on performance tests of ballbearings see:

These Methods Test Performance of Ballbearings, Sep 14, '59, p 78. Discusses special and commercial devices that check bearings for torque, vibration and runout characteristics. Article includes a selection table.

How to Measure Preload and Play in Ballbearings, Sep 28, '59, p 41. Discusses devices for measuring deflection, pre-load, contact angle, radial and play.

Both the above articles can be obtained free as a combined reprint by writing P 10 on one of the Reader Service cards.



High-strength film adhesive assembles all members of this helicopter rotor blade. (The adhesive joints are retouched black.)

WHY NOT WELD IT CHEMICALLY? —

a review of structural adhesives

This summary, extracted from a section in the forthcoming McGraw-Hill *Encyclopedia of Science and Technology*, emphasizes the compromises needed in selecting the best mating-part design, type of adhesive and fabricating technique when "chemical welding" is your structural joining method.

A F MARTIN

Adhesives, Coatings and Sealers Div
Minnesota, Mining and Manufacturing Co, St. Paul, Minn

Polymer chemistry is widening the range of resins for adhesives. The new formulations deliver special properties: flexibility, exposure resistance, shear strength, peel resistance. Result is that "chemical welding" becomes more competitive with bolting, riveting, brazing and conventional welding as a fastening method. For example, more than 80% of the B-58 jet bomber is assembled with structural adhesives.

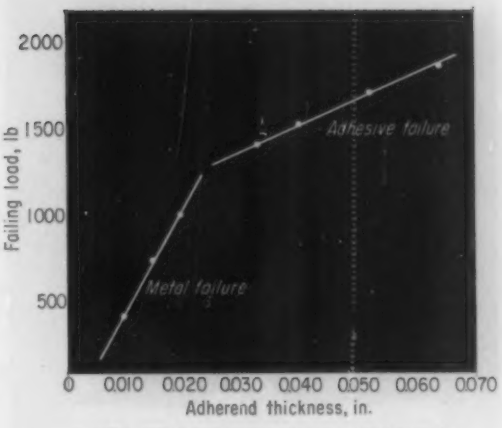
Also, a 1959 ASTM subcommittee, reviewing fatigue failures in aircraft, found no instances of bond failures, while the same conditions were found to cause metal fatigue failures.

But there are some limitations. Chemically welded joints are strongest in shear and tension, but are poor in peel and cleavage. This method of joining requires cleaner surfaces and tooling designed for intimate mating of the bonding surfaces during curing. Also, simple, nondestructive testing methods are not yet available for determining joint integrity, and in most cases these adhesives cannot be substituted directly for mechanical fasteners without redesign. Mating-part design, adhesive type and fabricating technique must be considered concurrently.

Basic requirement for adhesive use is to design parts so all of the bonded area carries load at the same time. Be-

yond that, adhesive properties and fabrication method must be considered.

- Adhesive selection requires a balance among: strength in shear, tension or peel; rate of load application; environment, including weather, temperature, fluids.
- Since these joints are strongest in shear and tension, the straight lapped joint is the most common design.
- Joint strength depends also on thickness and yield strength of the metal, but it is not directly proportional because increased deflection of the metal concentrates load at edges of the lap. A beveled edge reduces this concentration and increases joint strength.
- Properties of the material being joined also affect joint strength (see table). Adhesive shear strength increases with yield strength of the joined material.
- The bond can be no stronger than the surface it is attached to. For example, the alkyd primer on magnesium, or the resin-to-glass bond on the reinforced plastic, controls the joint strength.



Point of failure—metal or adhesive—depends on thickness of metal for a specific adhesive. Metal here was 2024-T3 clad aluminum, 75,000 psi tensile, with ½-in. lap joint; adhesive was nitrile-phenolic film; test temperature, 80 F.

TYPES OF ADHESIVES

No single system adequately classifies adhesives. Here are three that are common:

One is by bonding temperature—cold (below 68 F), room-temperature, or hot-setting (above 212 F). Most structural adhesives are hot-setting.

Another is by physical form—solvent solutions, non volatile liquids, or film. Solvent solutions are easily applied but give off the hazardous vapors; nonvolatile liquids range from paste to thin liquid and require only contact or mating pressure; film adhesives are of uniform thickness and avoid waste and shrinkage.

A third, by chemical type, while a means of classifying adhesives according to general chemical resistance, also provides a convenient basis for judging physical properties since the structural characteristics of the main chemical materials are pretty well known.

Phenolic modified elastomers combine nitrile or chloroprene rubbers, thermosetting phenolic resins and reinforcers; higher strength products usually contain vulcanizing agents for the rubbers and activators for the resins. These types combine peel strength, flexibility and vibration absorption with resistance to fuels, lubricants, humidity, and salt spray. Strength decreases slowly with increasing temperature, and excessive creep occurs at elevated temperature under any dead load higher than two-thirds the shear strength at that temperature. These modified elastomers do not self-fillet, a special problem in honeycomb construction.

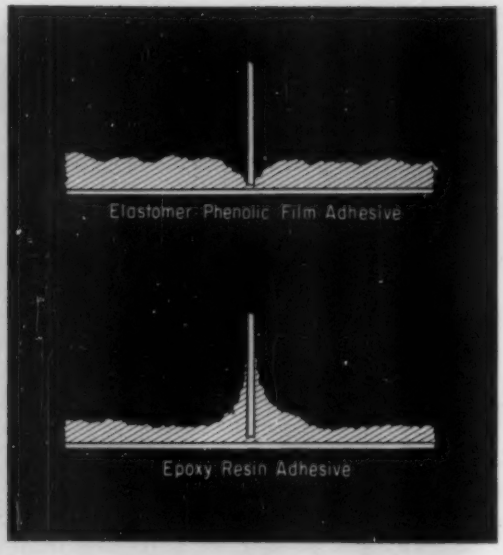
Chlorophene-phenolics have good shear and peel properties from −70 F to about 180 F, but their resistance to chemical attack and temperature is lower than with nitrile-phenolic film.

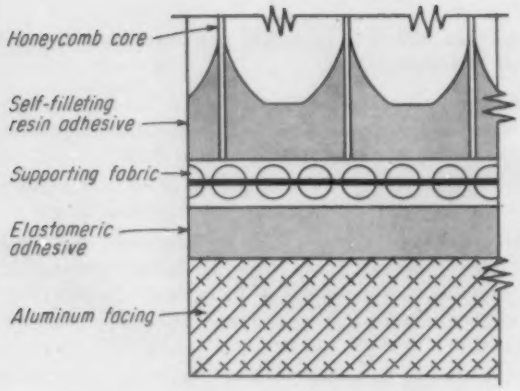
Vinyl-acetal resins such as polyvinyl butyal and polyvinyl formal are modified with phenolic resins to form compounds with good load-carrying ability in certain tem-

Effect of Material Strength on Strength of Adhesive Joints

Nitrile-phenolic Film Adhesive with ½-in. Overlap

Material	Surface Preparation	Thickness	Shear strength, psi, at temperatures of −67 F	80 F	180 F	300 F	500 F	Type of Failure
Aluminum 2024-T3 clad	Sulphuric acid, dichromate, water etch	0.064	3000	3700	2700	2300	700	Cohesive
Steel 17-7PH TH-1050	Nitric, hydrofluoric acid etch	0.051	3800	4750		2900	1580	Cohesive
Magnesium FS1-H24	Dow 7 conversion coating	0.064	1700	2700	1970	1250		Dow 7 coating pulled from magnesium
	Dow 7 plus baked alkyd primer	0.064	1100	2100	600			Primer coating pulled from Dow 7 coating
Plastic, polyester-glass	Sanded	0.125	1800	2120	1620			Resin delaminated from fabric
Plastic epoxy-glass	Sanded	0.125	2300	2700	2400			Resin delaminated from fabric





Composite film adhesive combines the high peel strength of elastomeric adhesive with the good filleting properties of epoxy. When applied to honeycomb panels the rubbery layer is applied to the facing, and the filleting layer to the core, with a supporting fabric between the two.

perature ranges. Vinyl phenolics give higher strengths at room temperature. They are used extensively with honeycomb sandwich; but the core is coated first, since the adhesive does not fillet.

Epoxy resins are usually nonvolatile liquids and have good self-filleting properties. Bonds have high strength at room temperature and excellent adhesion, but are brittle and have poor peel strength. Most of these adhesives are two-part products mixed just before application and cured chemically at room temperature.

Strength of the epoxy resins falls off with increasing temperature. Room-temperature-cured types lose strength rapidly above 150 F; heat-curing types must be selected for applications calling for elevated temperatures and resistance to humidity and salt spray.

Composite-film adhesives consist of a high-peel-strength elastomeric adhesive on one surface and a self-filleting epoxy adhesive on the other. When applied to honeycomb, the rubbery layer goes on the facing, the filleting layer on the core, giving the desired combination of peel and shear strength. Service temperature range is −70 F to 250 F. Less adhesive is required and production costs are reduced.

DESIGN FOR FABRICATION

Fabrication involves three steps; surface preparation, adhesive application, and curing; and all three must be specified to obtain the desired performance at lowest cost and minimum fabricating time.

Surface preparation must remove all contaminating substances: mold releases on plastic surfaces; paint, rust, oxide films, oil and dust from metal surfaces. Freshly cleaned surfaces must be protected by a primer if adhesive cannot be applied immediately.

Adhesive is applied by spray, brush, knife or film; for a solvent type, the solvent must be driven off before bonding.

Bonding requires heat and pressure for a controlled time, for all but the room-temperature-curing epoxy resins. Heat varies with type of adhesive, generally in the range of 330 F to 350 F. Rate of heating and cooling also influences bond strength: slower temperature rise reduces bonding pressure required but rise must be rapid enough to produce good wetting of the adherends before curing starts.

Pressure must be sufficient to uniformly mate all of the surfaces to be joined, and also to retain the adhesive during the cure. Fluid pressure has the advantage of following up the reduction in joint thickness as the adhesive flows prior to curing.

Cure time varies greatly with temperature—generally from 5 sec at 600 F to 2 hr at 250 F. Most adhesives develop best properties between 30 and 120 min. at 350 F.

EDITOR'S NOTE: These earlier articles include specific design data on structural adhesives:

How to Calculate Stresses in Adhesive Joints, July 7 '58, p 64. Analysis of six basic joints, with formulas for normal and shear stress.

Selection Guide for Sandwich-panel Adhesives, May 26 '58, p 56. Describes and tabulates properties for 14 widely used cements, including both thermosetting and thermoplastic.

Which Adhesive for What, Mar 17 '58, p 79. Applications and properties, for structural adhesives, and a shopping list of suppliers.

Adhesives for High Temperatures, Mid-Oct '57, p G25. Report on evaluation of an epoxy-phenolic cement, curing procedure and applications.

Assembly with Single-component Epoxy Adhesive, May '57, p 164. Thixotropic paste adhesive for industrial use requires no hardener.

Joint Design for Adhesive Bonding, Mid-Oct '56, p G-10. Defines basic factors in good joint design; adhesive-selection table for variety of adherend combinations.

Adhesive-bonded Metal Joints, July '55, p 170. Room-temperature tensile shear strength for eight adhesives; effect of loading rate on strength.

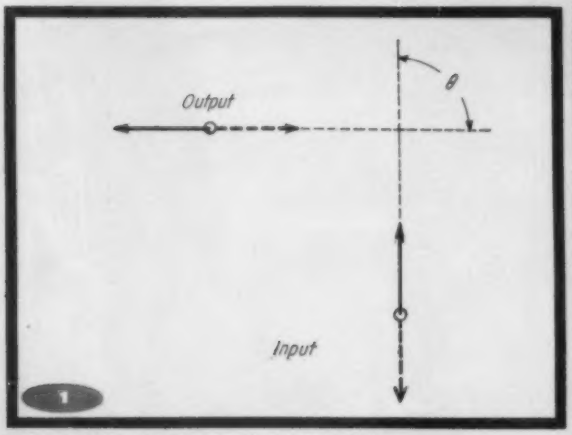
Adhesive Bonding, May '55, p 181. Design checklist for specification of formulation and process.

10 ways to change STRAIGHT-LINE DIRECTION

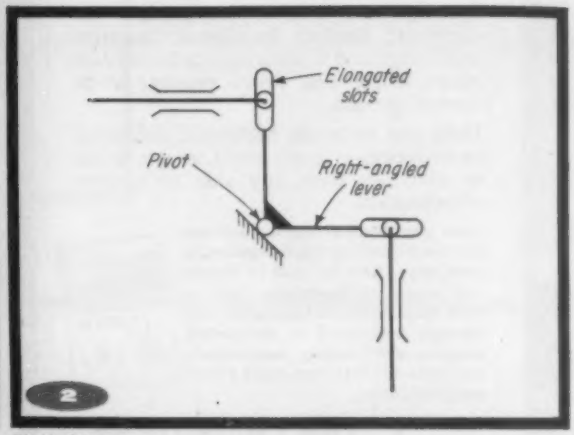
Arrangements of linkages, slides, friction drives and gears that can be the basis of many ingenious devices. Nine more arrangements—covering gears, cams, pistons and solenoids—will be presented next week.

FEDERICO STRASSER
Mankowitz & Strasser Ltd
Santiago, Chile

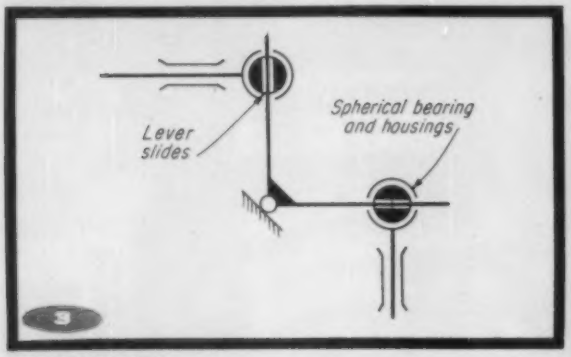
Linkages



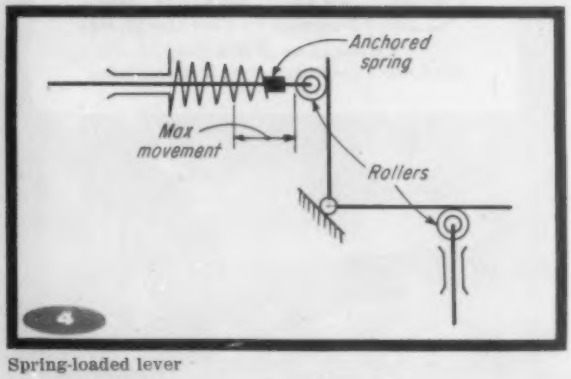
Basic problem (θ is generally close to 90°)



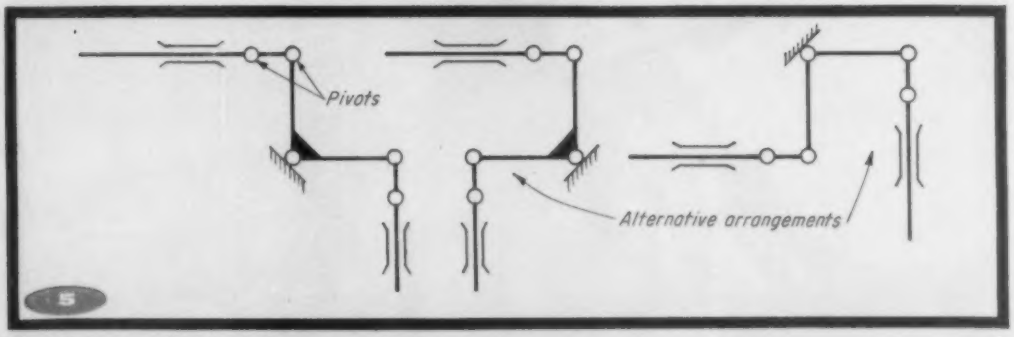
Slotted lever



Spherical bearings



Spring-loaded lever



Pivoted levers with alternative arrangements

continued on page 63

. . . FAST, UNIFORM PROCESSING — 1965 . . .

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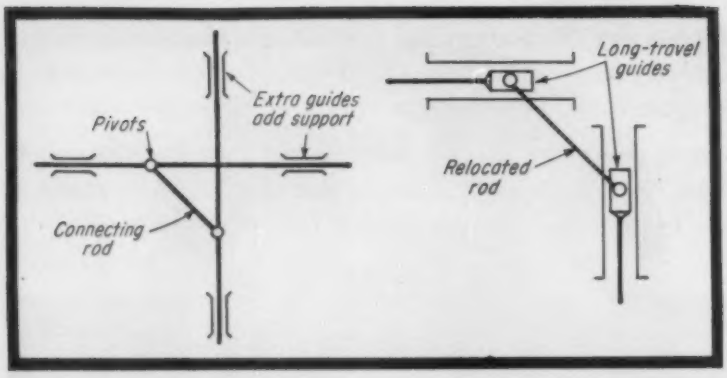
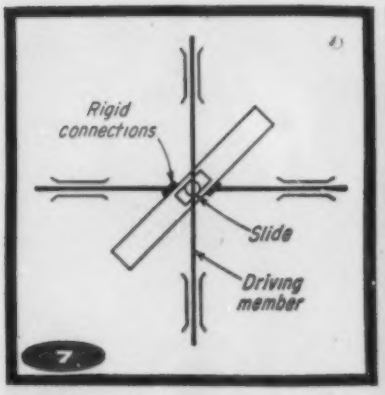
Guides

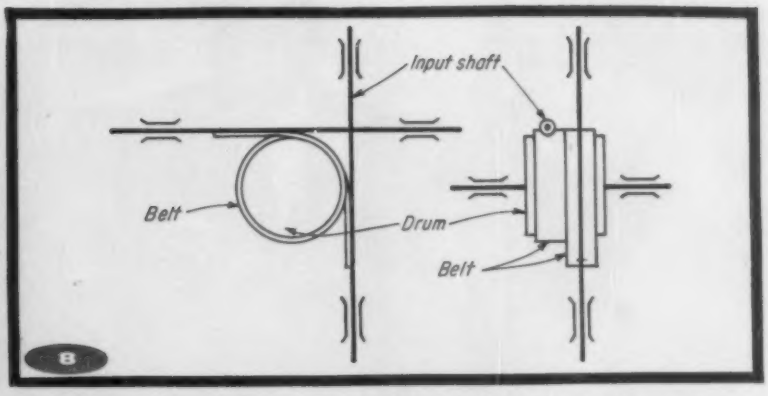


Single connecting rod (left) is relocated (right) to get around need for extra guides

Friction Drives

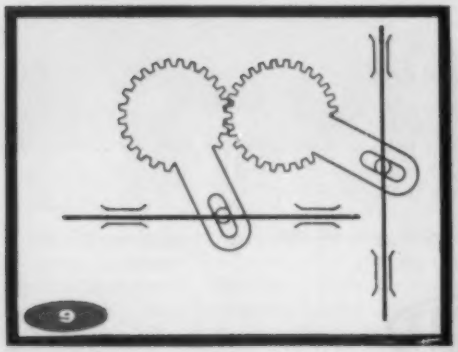


Inclined bearing-guide

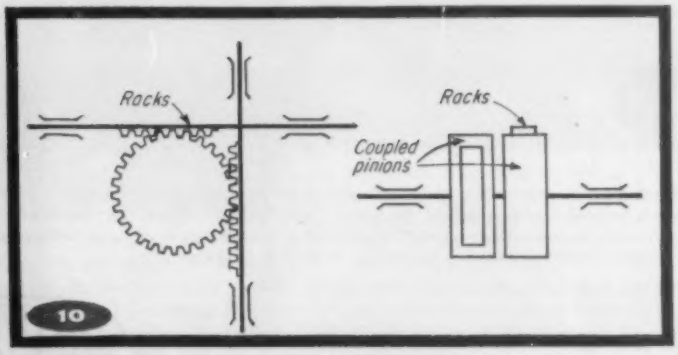


Belt, steel band, or rope around drum, fastened to driving and driven members; sprocket-wheels and chain can replace drum and belt

Gears



Matching gear-segments



Racks and coupled pinions (can be substituted by friction surfaces for low-cost setup)

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—North American Aviation, Inc., Los Angeles, California

North American Aviation, a leader in its field, uses CRONAFLEX *Engineering Reproduction Films for projection and direct positive printing. In addition to its incomparable stability,* CRONAFLEX *has other important advantages.*

*One North American spokesman puts it this way, "*CRONAFLEX *has excellent emulsion characteristics, too. Its speed and line density are remarkably uniform from batch to batch—an extremely important factor when you consider that we make upwards of 15,000 square feet of reproductions per month."*

CRONAFLEX *Films can cut time and costs in* your *plant, too. Ask your Du Pont Technical Representative for information or a demonstration. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.*

North American Aviation's Los Angeles Division photographic experts, left to right: Clay Chapen, Supervisor of the X-ray Photo Template Lab; Buzz Holland, Manager of Photographic and Reproduction Department; Bob Mease, General Supervisor of Photographic Services, inspect a CRONAFLEX print to be used by engineers working on the B-70 triple-sonic intercontinental bomber developed by the company for the U.S. Air Force.

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Printed-circuit motors . . .

for servo and instrument use are pancake-shaped rather than cylindrical. Light weight of rotating portion, about one-eighth that of conventional armatures, permits motor to reach full speed within a few thousandths of a second. May be used for direct drive in servo applications without gear trains. Offers smooth torque at low speed and low armature inertia. Armature inductance is reported not to exceed a few microhenries. Two sizes are now in production: 4¼ in. dia x 2¼ in. long and 5⅛ in. dia x 3 in. long. Available from stock after Apr. 15. In quantities of 1-15, motors are $190 and $240 each, according to size. (See PE—Mar 16 '59, p 64). **Photocircuits Corp, Glen Cove, NY.**

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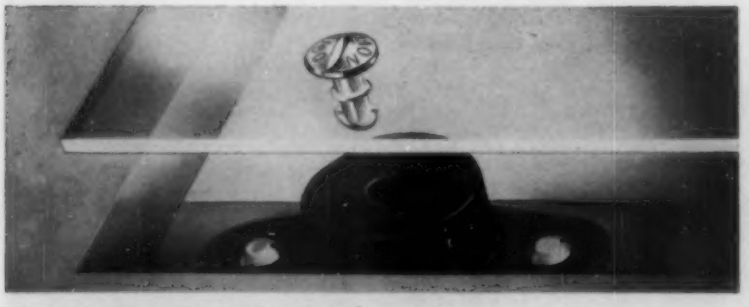


Vibration-mount quarter-turn fastener . . .

consists of standard No. 2 quarter-turn stud and retainer, with spring installed in special mounting assembly. Mounting assembly is aluminum plate to which 0.5-in.-thick neoprene-rubber boss is permanently bonded. Steel spring for closure is bonded into rubber boss. Two holes in mount facilitate installation. Available with studs in different sizes to meet varying thickness requirements. Each stud size handles particular min to max range of thicknesses. **Southco Div, South Chester Corp, Lester, Penna.**

Circle 301 on Reader Service Card

Sequential annunciator . . .

identifies sequence in which group of alarms occur. Any number of total alarm points can be handled. Three variations offer sequential identification of up to 7, 15 or 31 off-normal points by clear binary readout, with resolution between points in milliseconds. Alarms are audible as well as visible. Operator must reset after alarm. Each backlit panel light remains lighted until device it is monitoring returns to normal. Price, less than $100 per joint. Delivery to begin April '60. **Panalarm Div, Panellit Inc, 7401 N Hamlin Ave, Skokie, Ill.**

Circle 302 on Reader Service Card

Hydraulic suction filter . . .

with involute-design, wire-cloth filter element is said to give about three times normal cylindrical filtering area. At rated flows with 220-SSU mineral-base oil, pressure drop is 0.5 psi or less. Filter element provides approximately 10 sq in. of filtering area for each rated gallon of flow. In sizes for 1-, 1¼-, and 1½-in. pipe; rated for 10, 20, 30 and 50 gpm. **Arrow Tools Inc, 1927 S Kostner Ave, Chicago 23.**

Circle 303 on Reader Service Card

Three universal motors . . .

originally designed to power automotive wheel-balancing equipment, have open continuous ratings of ½ hp at 5000 rpm; ¾ hp at 7500 rpm; 1 hp at 10,000 rpm. All three are built in frame size 4334, have pad-type bases, net weight of 13 lb, 8⅞ x 5¾ x 5½ in. high. Standard motors, in aluminum housings, operate on 115 v dc to 60 cps ac and are nonreversible, rotating counter-clockwise at commutator end. **Robbins & Myers Inc, Springfield, Ohio.**

Circle 304 on Reader Service Card

75 durometer rubber sheet . . .

withstands heat aging at 500 to 600 F. Resists such chemicals as carbon tetrachloride, benzene and most mineral acids; fuels, oils and lubricants. Available from stock in molded sheets 12 x 12 and 24 x 24 in.; 3/32, 1/16, 3/32, 1/8 and ¼ in. thick. In small quantities, ⅛-in. thick sheet is $21.31 per sq ft. From stock. **Connecticut Hard Rubber Co, 407 East St, New Haven 9, Conn.**

Circle 305 on Reader Service Card

Thermal multicircuit switches

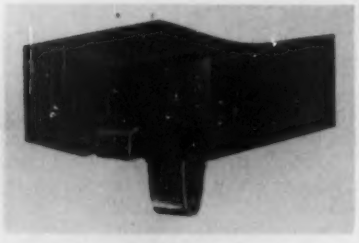
for thermocouple and resistance-thermometer applications provide from 2 to 20 circuits plus off-position with dummy-load contacts (for resistance-thermometer bridge protection). Available in explosion-proof, fungus-proof, splash-proof, sand- and dust-proof housings. **Winslow Co, 701 Lehigh Ave, Union, NJ.**

Circle 306 on Reader Service Card

Constant-voltage relay . . .

is said to maintain pull-in voltage to within 5% of nominal over temperature range of −85 to 185 F. Pull-in voltage may be chosen in 25- to 200-v dc range. Contact rating is 4 amp at 115 v ac or 32 v dc. Rated for life of 100,000 cycles. Withstands vibration of 20 g to 2000 cps, shock of 50 g for 11 millisec. **Hi-G Inc, Bradley Field, Windsor Locks, Conn.**

Circle 307 on Reader Service Card



Assembly and fastener bumpers . . .

for use as feet, bumpers, shock absorbers, vibration dampeners and insulating devices are offered in seven basic styles and designs. Assembly consists of rubber extrusion and spring-steel clip that retains the rubber and acts as fastener for entire unit. **Cooper Tire and Rubber Co, Dept 1-Q, Findlay, Ohio.**

Circle 308 on Reader Service Card

Electronic time-delay relay . . .

has standard delay times of 50 millisec to 3 min. during operate or release cycle. Said to achieve accuracies of 10% or better over severe environmental conditions with vibration to 20 g, 2000 cps; temperatures of −85 to 257 F; and shock of 50 g. Contacts are available with ratings to 10 amp. Ac or dc source voltages may be specified. **Hi-G Inc, Bradley Field, Windsor Locks, Conn.**

Circle 309 on Reader Service Card

Self-seating hydraulic fitting

has straight thread and consists of stem and body with floating nut. Tightening nut forces stem to coin its own seat. ½-in. fitting requires 1 in. center-to-center space. Makes positive metal-to-metal seal without O-rings. For use in hydraulic, pneumatic, lubrication, instrumentation and other fluid systems. Available in OD sizes from ¼ to 2 in. and all conventional shapes. **Flodar Corp, 16911 St Clair Ave, Cleveland 10.**

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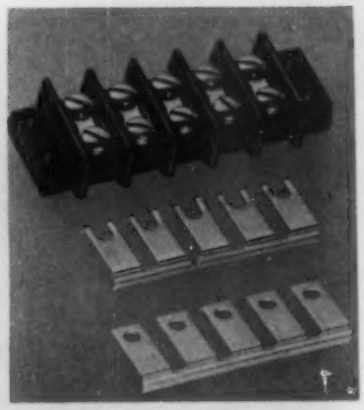


Jumper wiring strips . . .

eliminate need for usual series of jumpers between terminal stations on multiple adjacent-station connections. Single-piece units are made of nickel- or cadmium-plated brass. For use on Kulka series 601 terminal boards or Navy types 6TB or 7TB. Available with up to 23 connecting lugs. **Kulka Electric Corp, 633-643 S Fulton Ave, Mt Vernon, NY.**

Circle 311 on Reader Service Card

Semiconductor strain sensor . . .

is applicable to strain gages said to have sensitivities 50 times greater than present metallic devices. Microminiature sensing mechanism, which measures 0.0001 in. dia by about ¼ in. long, is also applicable as transducer in measurement of pressure, linear and angular acceleration, vibration, displacement and force. Sensing element responds to change in electrical resistance when element is subjected to physical stress. Reported to have ultimate gage factor of 175 compared to less than five for wire strain elements now in use. Sensing elements can be made to operate at ambient temperatures to 1000 F. **Electro-Optical Systems Inc, 170 N Daisy Ave, Pasadena, Calif.**

Circle 312 on Reader Service Card

Electronic counters . . .

measure frequency and random events per unit of time directly. With transducers converting mechanical into electrical phenomena, they also measure speed, rpm, rps, weight, pressure, temperature and acceleration. One model has 5-place readout; another has 4-place readout. Frequency range is 1 cps to 120 kcps. Accuracy is 0.01% ± 1 count. Display time can be adjusted from gate time to about 15 sec or can be held until reset. 4-place unit, $675; delivery, 8 wk. 5-place counter is $875; delivery, 1 wk. **Hewlett-Packard Co, 275 Page Mill Rd, Palo Alto, Calif.**

Circle 313 on Reader Service Card

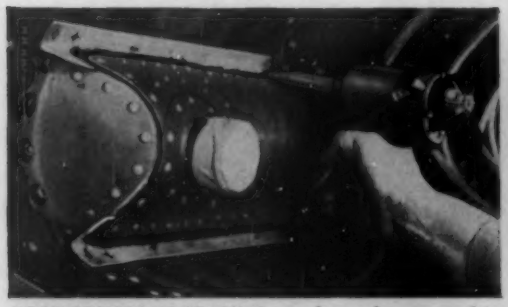
Structural steel tubing . . .

is available in girths from 12 to 48 in. and wall thicknesses of ⅛ to ½ in. Thus it is possible to order square tubing from 3 x 3 in. to 12 x 12 in. and rectangular tubing in sizes from 4 x 2 in. to 14 x 10

continued on page 68

General Electric RTV silicone rubber

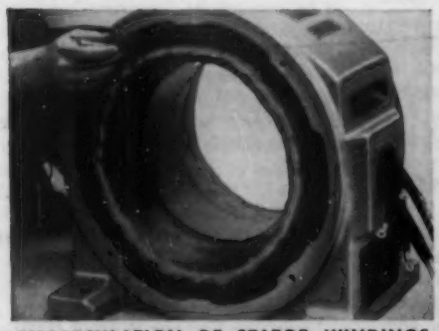
New liquid rubber cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.



HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.

LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.



ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.

POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.

RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section A214 General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

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in. Cut to exact length. Tubing is brake-formed for longitudinal accuracy. Commercially straight up to 24 ft. **Union Asbestos & Rubber Co, Espro Tubing Div, 332 S Michigan Ave, Chicago.**

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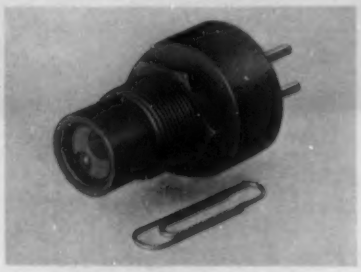

Miniature single-unit scanner

combines infrared light source and photocell detector into unit that is 2¼ x 1⅛ in. dia. Operates on reflected light. Responds to metal and non-metallic objects and controls areas at distances up to 2 in. Standard, four-prong base permits plug-in connection to control circuit. List price, $29. Delivery, 2 wk. **Farmer Electric Products Co Inc, 2300 Washington St, Newton Lower Falls, Mass.**

Circle 315 on Reader Service Card

Double-break enclosed switch

can be wired as SPDT switch with series contacts that break each circuit in two places at once; as SPDT switch with contacts paralleled to give decreased contact resistance; or can provide SPST, double-break action in two separate circuits. Rated 10 amp at 125 or 250 v ac. Switch is 2⅛ x 1⅜ x 2½ in. Weighs 3 oz. **W L Maxson Corp, Ives Rd, Wallingford, Conn.**

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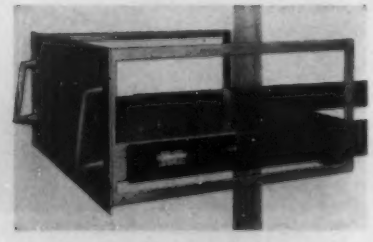

Electronic chassis slides . . .

cannot over-ride latching mechanism no matter how fast chassis is withdrawn from electronic cabinet. Unit can mount standard 17-in.-wide chassis in standard electronic cabinets with 17¾ in. clear opening. Cabinet section is 2 7/16 in. high. Unit is rated to carry 220 lb in extended position. Rotating and nonrotating models supplied. Stock lengths are 10 to 26 in., in 2-in. increments. Prices range from $18.70 to $46.70, depending upon model size and quantity. Delivery from stock. **Electro-Pack Inc, 11505 Jefferson Blvd, Culver City, Calif.**

Circle 317 on Reader Service Card

Shaft-angle encoder . . .

converts linear input to sine-cosine functions. Code disk contains sine and cosine information in cyclic binary form. Accuracy of instrument is said to be 2" ± 1 bit of sine or cosine value. Has 23 or 35 synchro mount with 3¾ in. OD and over-all length of 6½ in. When used with servo shaft positioner, conversion from linear to sine-cosine can be accomplished without storage or computational facilities. **Dychro Corp, 49 Walnut St, Wellesley 81, Mass.**

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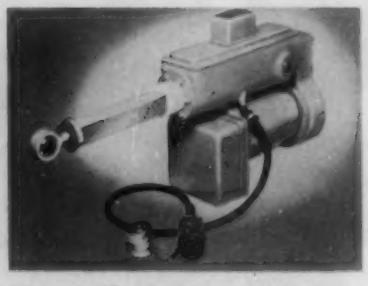

Electrically driven actuator . . .

is linear, heavy-duty unit for open-loop positioning applications. Can move up to ¾ ton and can hold 1½ ton. Brake is used to reduce over-coast to minimum. Stroke is continuously adjustable from 4.25 to 5.25 in. Also available is second version of actuator, which offers shorter stroke of 2.75 to 3.75 in. Powered by single-phase, 115-v, 60 cps motor capable of developing 0.14 hp at 5000 rpm. Fits into 16-lb envelope. **Lear Inc, PO Box 688, Grand Rapids 2, Mich.**

Circle 319 on Reader Service Card

Frequency-flow-rpm counter . . .

offers in-line Nixie readout and modular construction. With appropriate sensors, reads directly in cps, fpm, rpm or any physical variable that can be converted to proportional frequency. Electrical events counted during standard selected gating interval of 1/10 or 1 sec are held during adjustable display time of 0.2 to 6 sec or indefinitely until manually reset. Frequency range is 0 to 120,000 pulses per sec; 1 to 120,000 cps. Accuracy, ± time base stability, is ± 1 count. Standard unit, with 60-cps time base, is $525 for 4-decade unit; $595 for 5-decade unit; $665 for 6-decade unit, FOB Hawthorne. **Erie-Pacific, Div of Erie Resistor Corp, 12932 S Weber Way, Hawthorne, Calif.**

Circle 320 on Reader Service Card

Single-acting cylinders . . .

for hydraulic service, range from 4 to 8 in. dia, with length to specifications. Offer capacities up to 75,000 pounds. Available in operating pressures up to 500 psi. Hydraulic piston within steel cylinder moves on removable, precision bronze bearings. **Joyce-Cridland Co, 2027 E First St, Dayton 3, Ohio.**

Circle 321 on Reader Service Card

Cumulative hour meters . . .

indicate, in hours and minutes, operating time, to 100,000 hr, of any machine, tool or equipment run with 120 or 480 v ac. Available in 2½ and 3½ in. dia, 2.94 in. over-all depth. **Hobbs Div, Stewart-Warner Corp, Springfield, Ill.**

Circle 322 on Reader Service Card

Preprinted adhesive film . . .

is transparent. Printed to order on 0.0015-in.-thick acetate. Left untouched for about 24 hr, film sets to permanent bond with paper or cloth to which it is applied. Unprinted film is also usable as mending tape for torn drawings and is available in narrow rolls for this purpose. Matte outer surface permits use of pen, pencil or typewriter. Available in 20-yd rolls of various widths and in sheets sized to order up to 18 x 24 in. **Keuffel & Esser Co, 3rd and Adams Sts, Hoboken, NJ.**

Circle 323 on Reader Service Card

Epoxy-base paste material . . .

is 2-part resin-hardener that cures in up to 30 min. Dimensional stability is reported to be maintained, with shrinkage of 0.003 in. per ft. When sealed properly, material will not absorb moisture. Clings to vertical, horizontal and circular surfaces, despite high temperatures. Can be used as substitute for plaster of paris, as filler or as glue. **Ren Plastics Inc, 5422 S Cedar Rd, Lansing 9, Mich.**

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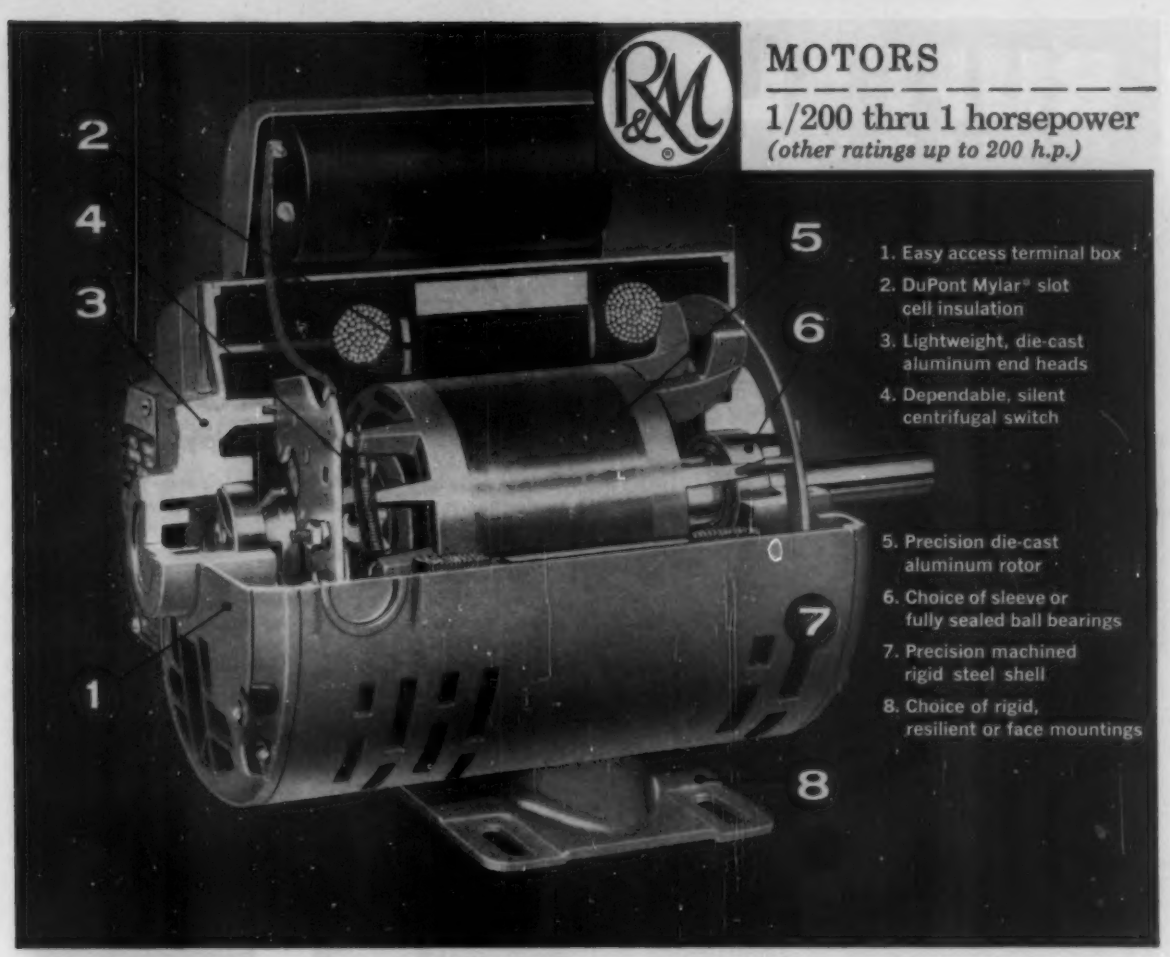
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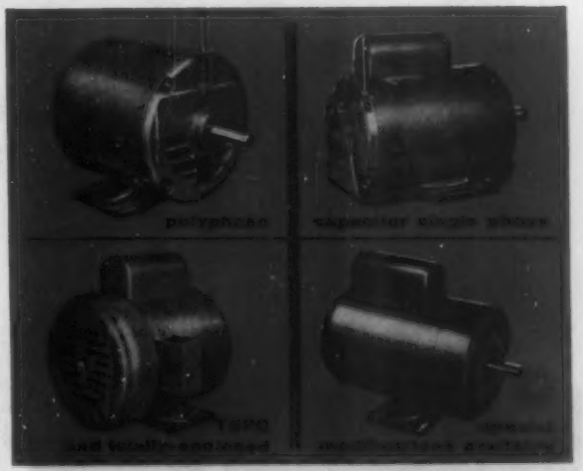

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RF & C RUBBER COVERED BELTING	
Natural Rubber	abrasion, water, weather, mild acids
Neoprene	abrasion, water, weather, grease, oil, acids
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DESIGN LITERATURE

A Source Book in Mathematics

Edited by DAVID E SMITH. Dover Publications Inc, 180 Varick St, New York 14. 2 vols (paperback), 6 x 5⅜, 700 pp (total). $1.85 per vol.

This two-volume anthology is a paperbound reprint of book originally published in 1929. These volumes contain selections from 125 mathematical treatises and articles that have had a tremendous impact on world history. Demonstrating the lasting importance of mathematics are these facts: The theory of electricity was implemented by Dedekind's imaginary numbers; electronic circuits are designed according to the calculus of Newton and Leibniz; precision mass production was made possible by the theory of probability developed in the writings of De Moivre and Fermat, and the mathematics of Bernoulli and Galois was used to break the Japanese secret code in World War II.

Reading through this well-documented anthology recalls a remark by Bertrand Russell, "Mathematics possesses not only truth, but supreme beauty. . ." —BAL

Turbulence

J O HINZE. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6¼ x 9½. 586 pp. $15.

This book gives fundamentals of turbulent flows, useful for theoretical investigations of chemical engineering problems such as mixing and heat-and-mass transfer, in which turbulence plays an essential part.

Chapter 1 gives a general introduction to turbulence theories and derives basic formulas that are utilized in later chapters. Chapter 2 deals with methods and instruments commonly used in measuring turbulence qualities. Remaining chapters cover isotropic and nonisotropic turbulence, transport processes, nonisotropic free turbulence and turbulent flow along fixed walls. The appendix contains an introduction to Cartesian tensors.

Electronic Switching, Timing, and Pulse Circuits

JOSEPH M PETIT. McGraw-Hill Book Co Inc, 330 W 42nd St, NY 36. 6 x 9, 267 pp. $7.50.

Tubes and transistors are used primarily as switches in many circuits and the resulting waveforms of current or voltage may be rectangular, triangular, or a succession of short pulses, but in almost no case will they be sine waves. There is widespread use of such waveforms in many electronic systems, including television, radar, pulse communication, digital computers and instrumentation.

This book—covering the above topics—is not at all encyclopedic on either circuits or applications but gives the basic analytical techniques. Analysis is based upon the graphical representation of tube or transistor characteristics, approximated by linear segments. Among the recent advances covered are: the newer types of NPN transistors and special circuits such as the sanatron. Examples are based on practical contemporary circuits and components, including both tubes and transistors.

Magnetic and Electrical Fundamentals

ALEXANDER EFRON. Vol. 8, Basic Science Series, John F Rider Inc, 116 W 14th St, New York 11. 5½ x 8½, 132 pp. $2.50.

This book presents magnetic and electrical fundamentals, utilizing the Franklinian approach. The emphasis is on physics. The author lucidly explains the physics of magnetism and electrical fundamentals. Such information is extremely valuable to students and those engaged in work where a knowledge of such phenomena is required.

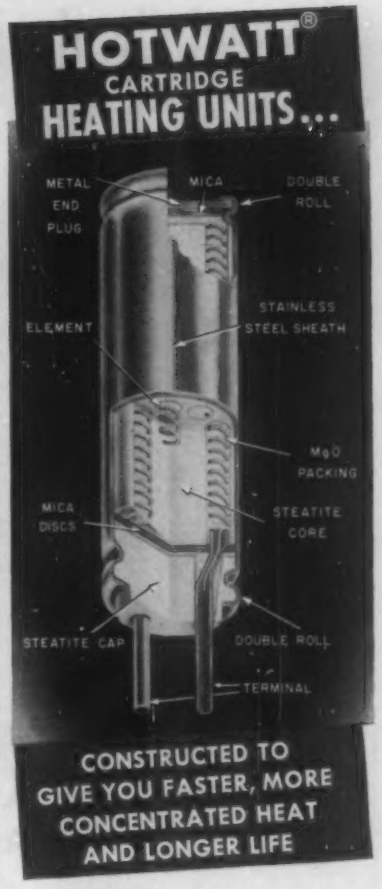
Two on Magnetism

"Magnetism and Electromagnetism" A SCHURE. Vol. 20, Electronic Technology Series, John F Rider Inc, 116 W 14th St, New York 11. 5½ x 8½, 78 pp. $1.80.

"Advanced Magnetism and Electromagnetism" A SCHURE. Vol. 26, Electronic Technology Series, John F Rider Inc, 116 W 14th St, New York 11. 5½ x 8½, 104 pp. $2.25.

Volume 20 deals with those aspects of magnetism and electromagnetism that underlie the operation of communication and industrial electronic devices. The major theoretical considerations of magnetism, magnetic circuits, and electromagnetism are considered at the intermediate level. The mathematical techniques used are simple but extensive enough to

continued on page 72



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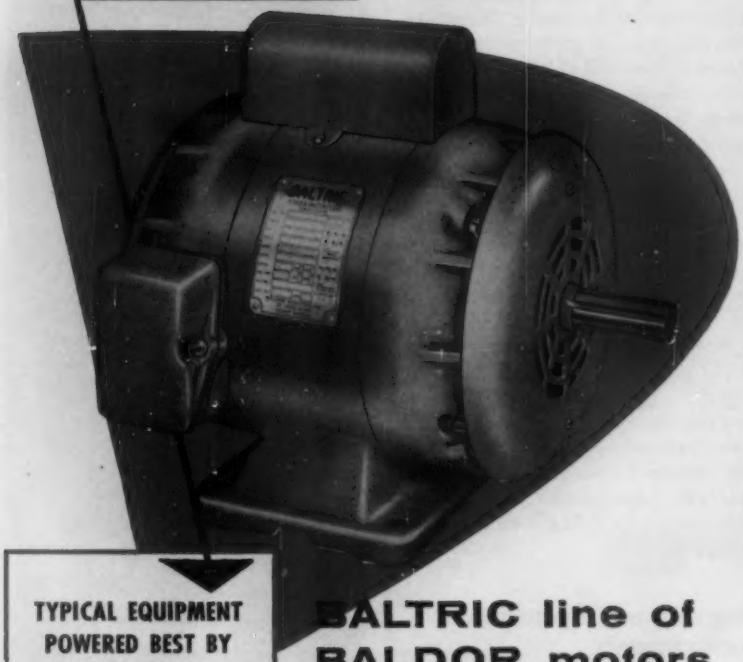

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develop familiarity with typical computations.

Volume 26 is devoted to the explanation of the various underlying magnetic and electrical phenomena. It concerns itself with the details of the force acting on a charge moving through a magnetic field, induction lines, magnetic flux, Biot's Law, Faraday's Law, Lenz's Law, and the Curie-Weiss Law. Interesting material is presented on the domain theory of magnetism. Also covered are such items as the cyclotron, the mass spectrograph, and terrestrial magnetism.

Review problems are given at the end of each chapter. Each chapter contains numerical examples which illustrate the application of the equations.

ABSTRACTS FROM THE LITERATURE

Fastener-torque Selector

Suggested max torque values for fasteners of different materials are given in a full-page table, arranged according to bolt size (from 2-56 to 1½ in.-12).

"A Guide to What Torque a Fastener Should Have," John A. Stevenson, H. M. Harper Co; Fasteners, Vol. 14, No. 4. Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13.

Calculating Bearing Loads

Origins, nature, distribution of loads imposed on ball and roller bearings are described. Torque produced by input horsepower is discussed. Effects of belt, rope and chain drives, and arrangements of spur gearing are also included.

"Hints on Calculation of Bearing Loads," R&M Bearings Canada Ltd. Design Engineering, Jan '60, 481 University Ave, Toronto 2, Ont.

Welding of Foil

Inert-gas-shielded tungsten-arc welding is particularly adaptable for the welding of butt joints in foil. However, careful consideration of a number of process variables is essential. Only by control of these variables through good design of all components of the welding equipment can foils of 0.002-, 0.003-, and 0.005-in. thicknesses be welded.

Accurate preparation of the joint edges is essential to achieve success-

continued on page 75

(Advertisement)

the LEAD newsletter

Name your technological field . . . electronics, thermoelectrics, cryogenics, atomic energy, chemicals, construction, ceramics, or whatever . . . it's safe to assume that ubiquitous lead plays a vital part in some facet of it. One reason why lead is found in so wide a variety of uses is *research*. The Lead Industries Association is sponsoring a worldwide cooperative research program in lead conducted in universities, private and public research institutions and individual companies. This is in addition to heavy research expenditures on lead conducted by companies both in and outside of the lead industry and governmental agencies. To keep lead one step ahead of the latest technological developments, LIA also makes every effort to keep informed on all lead research, both its own and that of others. Some areas of current intensive investigation . . . and the results already achieved . . . are outlined in the following paragraphs.

Electronics

Ultra low-loss lead-fluxed ceramic dielectrics have already been perfected by LIA-sponsored research and put to use by commercial electronics manufacturers. Currently, LIA-sponsored research in this field is centered on developing a new ultra low-loss ceramic dielectric incorporating alumina as the main crystalline compound.

Lead piezoelectrics have opened the doors to many applications involving conversion of electrical to mechanical energy and vice versa. Stereophonic pick-ups, for example, have been made of lead zirconate-titanate. This material also greatly increases the operating range of missile devices, sonar transducers, ultrasonic equipment, and many other systems.

Vibration

Although lead has been known as a vibration damp for many years, LIA-sponsored research is designed to develop engineering data which it is expected will add new dimensions to lead's effectiveness in vibration control. Lead asbestos pads, for instance, were used in the foundations of the new Union Carbide skyscraper in New York . . . right over the dense network of railroad tracks leading into Grand Central Station! And, for the first time, they have been used to isolate vibration of a roof-top air-conditioning cooling tower on a New York skyscraper.

Organolead Chemicals

LIA is financing several extensive research projects, both here and abroad, in the field of lead chemicals with particular emphasis on organolead compounds. While tetraethyl lead has long been the shining example of commercially valuable organometallics, many other organolead compounds are being synthesized and their properties studied for industrial usefulness.

Cryogenics

A large amount of scientific study is being devoted to the amazing conductivity properties of lead at temperatures several hundred degress below zero. At this point, lead does a complete about face from its normal characteristics of being a poor conductor of electricity and becomes a superconductor. Researchers are currently at work to capitalize on this phenomenon in computers and similar equipment which, as a result, might be significantly reduced in size.

Emissivity

Certain lead compounds . . . such as PbSe, PbS, PbO, and PbTe . . . have exhibited interesting heat emissive properties. Basic research is being conducted into the why's and wherefore's of this performance . . . and the possibilities of utilizing these properties to improve the efficiency of commercial heating and refrigeration systems. To date, the work has been concentrated on obtaining the room temperature emission properties of lead telluride, which is expected to have the highest emissivity of the compounds under consideration.

Ceramics

Research in a variety of ceramic applications has already brought on the market several new and useful products such as lead-containing porcelain enamels for coating aluminum . . . lead glazes on bricks and light aggregate blocks . . . and leaded porcelain enamel for coating chalkboards made of thin steel. Current research is intensively investigating the wettability of lead glazes on structural clay bodies with respect to clay body composition, lead composition of the frit, and firing atmosphere, and low-firing porcelain enamels for steel.

Sound

While lead is already noted as a sound isolation medium . . . heavily leaded plastics are currently being used for this purpose in the latest jet aircraft and helicopters . . . a continuing project is currently underway that entails a feasibility study for employing lead products in architectural structures for sound isolation.

Anodes

Impressed current systems . . . for the protection of iron and steel against corrosion . . . are coming under much study by industry. Lead alloy anodes are showing exceptional results in research programs dealing with this subject. Already, installations have been made on ships, piers, bridges and other structures.

No matter what *your* problem, there's a good chance that lead may well provide your best solution. Why not find out? All you need do is write for the free advice of our scientists and researchers. The address: Office of Technical Information, Lead Industries Association, 60 East 42nd Street, New York 17, N.Y.

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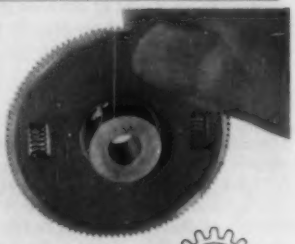

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ful welds. Shearing, slitting and milling techniques are discussed with respect to their applicability to edges for welding.

"Control of Process Variables—Key to the Successful Welding of Foil," John Campbell, Central Research Laboratories, Air Reduction Co, Murray Hill, NJ. Welding Journal, Dec '59, 33 W 39th St, New York 18.

Engineering the Engineer

Tells how typical industrial engineering techniques for obtaining optimum production from personnel and equipment might be applied to engineering groups and organizations. Considers effect on such elements of engineering as work programs, liaisons with other departments, use of specialized technical aid, administrative systems.

"Utilizing Industrial Engineering in Engineering Management," James L. Rigasso, Newark College of Engineering; ASME paper 59-A-244. ASME, 29 W 39th St, New York 18.

How Surface Condition Affects Paint Performance

The condition of the surfaces of steel products produced and finished by various processes and materials are discussed. Describes methods of identifying type of surface contamination, and suggests means of altering steel production practices to improve surface quality.

"The Influence of Cold-rolled Steel Surfaces on Paint Performance and Paint Testing," G. W. Grossman, Jr, Q-Panel Co; Official Digest of Federation of Societies for Paint Technology, Dec '59, 121 S Broad St, Philadelphia 7.

Epicyclic Gear Trains

Develops a method of synthesizing compound epicyclic trains using the concept of a velocity ratio spectrum. To facilitate application, only one train in a compound epicyclic train is regarded as basic; all others are considered as serving to modify motion of controlling element in basic train.

"Synthesis of Epicyclic Gear Trains Using the Velocity Ratio Spectrum," R. C. Brewer, University of London, England; ASME paper 59-A-22. ASME, 29 W 39th St, New York 18.

Engineering Organization

Some of the key factors in optimum organization methods for engineering groups are discussed, based on organization philosophy, qualifications of personnel, administration responsibilities, interdepartment relations, re-

continued on page 77

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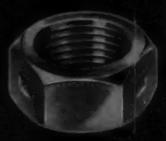

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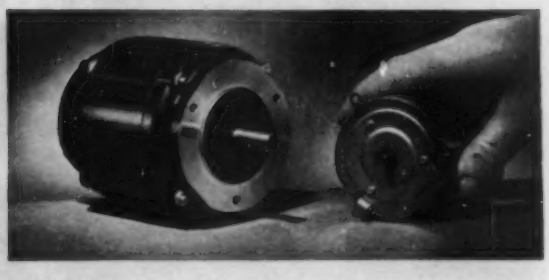

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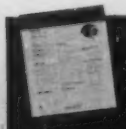

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"Modernized Engineering Organization," Charles E. Paules, Esso Research & Engineering Co; ASME paper 59-A-245. ASME, 29 W 39th St, New York 18.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

MOISTURE-DETECTION SYSTEMS—Catalog 660, 68 pp. Descriptions and illustrations of moisture-detection, control and alarm equipment. American Instrument Co Inc, 8030 Georgia Ave, Silver Spring, Md.

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SCREW-THREAD ROOTS—Pamphlet, 20 pp. Provides basic criteria for good thread roots; comparative analysis of three widely used thread forms; specification for large, round root radius; capsule history of evolution of this design aspect of the thread; preview of anticipated standards. Standard Pressed Steel Co, Box 545, Jenkintown, Penna.

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ELECTRIC POWER DRIVES—Catalog 258, 68 pp. Covers over 8000 ratings, prices, dimensions and specifications for squirrel-cage motors, gearmotors, speed reducers, right-angle gearmotors, right-angle, variable-speed drives and variable-speed drives. Sterling Electric Motors, 5401 Telegraph Rd, Los Angeles 22.

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NUMERICAL CONTROL OF MACHINES—Guide book, 20 pp. Basic information and approximate costs of applying tape-control to machining operations. Ex-Cell-O Corp, 1200 Oakman Blvd, Detroit 32.

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VACUUM-INDUCTION MELTING—Brochure, 36 pp. Discusses process and applications of alloys produced. Property charts compare characteristics of vacuum-induction-melted alloys with those of conventional high-temperature alloys. Metals Div, Kelsey-Hayes Co, Dept 17, New Hartford, NY.

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FUNCTIONAL DRAFTING—Supplement 2, 32 pp. Presents information on effects of equipment on drafting efficiency and fatigue. Discusses six basic areas in which personnel attitudes, systems and equipment must be developed in order to reduce drafting and design costs. Kuhlmann Straube Co Ltd, PO Box 358, Oakville, Ont, Canada.

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AIR REGULATION—Catalog, 24 pp. Incorporates slide rule for selection of pneumatic pressure regulators. Gives performance and installation information on more than 25 pressure regulators, volume boosters, air relays. Stratos Div, Fairchild Engine & Airplane Corp, Rte 109, W Babylon, NY.

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DC POWER SUPPLIES—Catalog, 16 pp. Specifications for standard line of 75 power supplies. Selection chart is included. Dressen-Barnes Corp, 250 N Vinedo Ave, Pasadena, Calif.

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STOCK ELECTRONIC COMPONENTS—Stock catalog 30A, 32 pp. Lists rheostats, potentiometers, resistors, relays, variable transformers, tap switches, chokes, capacitors and miscellaneous components available for immediate delivery. Includes specifications and prices. Ohmite Mfg Co, 3695 Howard St, Skokie, Ill.

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INVESTMENT CASTING—Brochure, 14 pp. Explains ceramic-shell investment casting and discusses company facilities. Hitchiner Mfg Co Inc, Milford 30, NH.

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SILICONE PRODUCTS—Bulletin CDS-129B, 8 pp. 1960 guide to line of silicone products, major uses and characteristics. General Electric Co, Waterford, NY.

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MARINE HYDRAULIC COMPONENTS—Bulletin 202, 8 pp. Outlines use of hydraulic pumps, motors and valves for commercial and military marine use. Gives operating characteristics of pumps and fluid motors for service up to 5000 psi. Denison Engineering Div, American Brake Shoe Co, 1160 Dublin Rd, Columbus, Ohio.

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STANDARD AND SPECIAL NUTS—Brochure, 12 pp. Condensed version of 144-pp catalog. Includes dimensions, performance information, specifications and characteristics. National Machine Products Co, Utica, Mich.

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AUTOMATIC WAVE ANALYSIS—Bulletin DB-905A, 16 pp. Describes and illustrates systems for Fourier and spectral power studies. Minneapolis-Honeywell Regulator Corp, 10721 Hanna St, Beltsville, Md.

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SURFACE-FINISH MEASUREMENT—Bulletin LT14, 8 pp. Features and applications of direct-reading instrument for measuring surface finish. Micrometrical Mfg Co, 345 S Main St, Ann Arbor, Mich.

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CORROSION RESISTANCE—Chart J-CRC, 4 pp. Lists over 150 chemicals and their recommended usage with duc-

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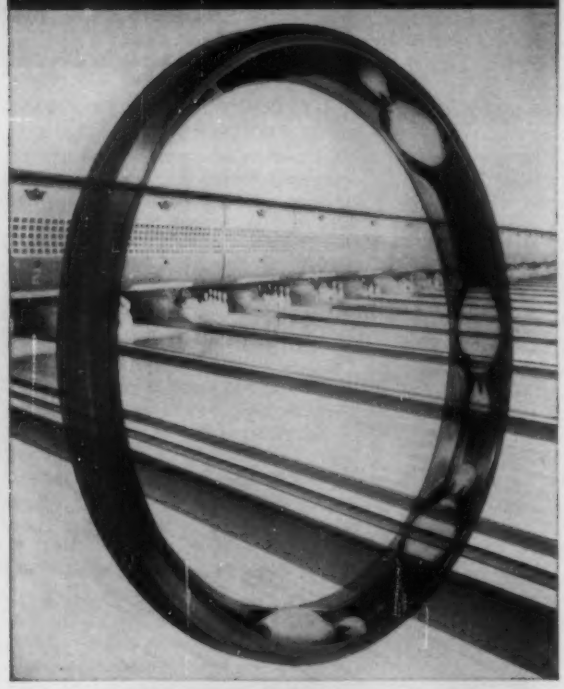

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PEAK-PRESSURE GAGE—Folder, 4 pp. Describes and illustrates hydraulic peak-pressure gage. Gives specifications, method of operation and performance information. Hydel Inc, Dept B, 223 Crescent St, Waltham, Mass.

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MECHANICAL SEALS—Data folder, 4 pp. Two nomograms facilitate determination of frictional-heat and power absorption for rotating mechanical seals. Also includes max permissible shaft speeds for rotating spring-type seals and PV ratings for type RR seals. Sealol Corp, 231 Post Rd, Providence 5, RI.

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MAGNETIC PULLEYS—Bulletin B-50-1A, 6 pp. Covers permanent-magnetic pulleys, with dimensions, capacities and performance characteristics. Eriez Mfg Co, Erie 6, Penna.

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STRAIGHT-THREAD CYLINDER PORTS—Bulletin supplement S-113-1A, 2 pp. Covers advantages of using straight-thread ports for hydraulic cylinders. Also contains table for determining proper port sizes for 1¼ through 8-in. bore cylinders. Hannifin Co, Dept 126, 501 S Wolf Rd, Des Plaines, Ill.

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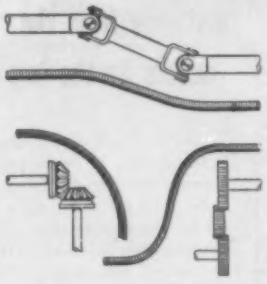

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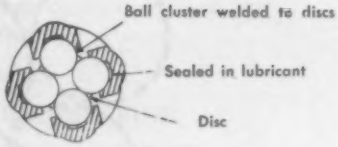

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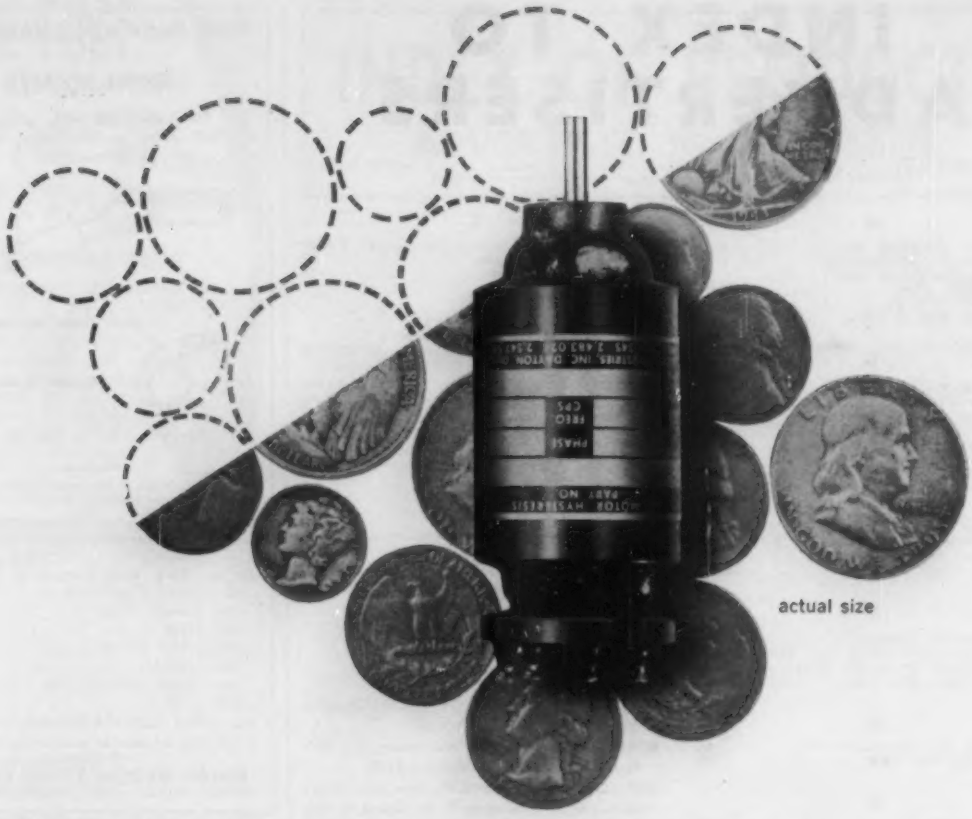

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Gasket engineering

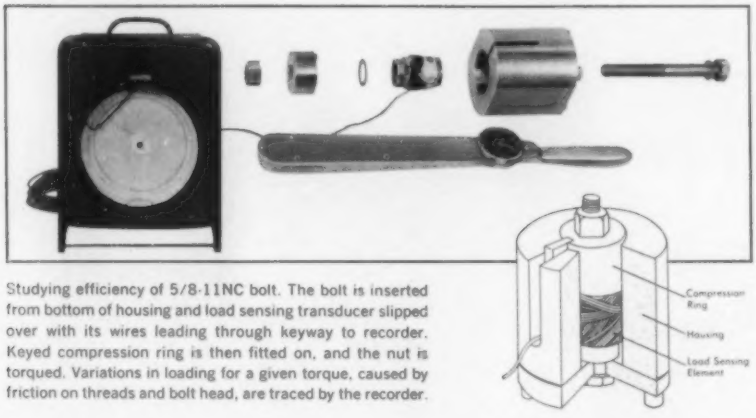
BOLT EFFICIENCY and FLANGE LOADS

Gasket leaks are most often caused by inadequate flange pressure. One reason: bolt friction soaks up torque, produces wide variations in bolt efficiency, makes flange load calculations unreliable.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

Adequate flange pressure is the single most important factor in the success of a gasketed seal. In fact, if sufficient flange pressure is available, many gasket problems arising from other considerations might never become serious.

Although it is generally known that friction causes variations in bolt efficiency, little data has been available to indicate the extent of the problem. As a result, arbitrary compensations for friction are usually on the low side.



Studying efficiency of 5/8-11NC bolt. The bolt is inserted from bottom of housing and load sensing transducer slipped over with its wires leading through keyway to recorder. Keyed compression ring is then fitted on, and the nut is torqued. Variations in loading for a given torque, caused by friction on threads and bolt head, are traced by the recorder.

Calculating flange loads is a relatively simple matter when the number, size and torque of bolts are known. Leaks often occur, however, in gasketed joints where flange loads as calculated are thought to be adequate . . . or more than adequate . . . to form a seal.

Such leaks are sometimes blamed on torque loss, but the real problem usually is that the flange pressure is too low to form a seal. And the reason is that flange loads arrived at mathematically almost never equal the true load on the gasket.

The explanation is friction . . . friction on threads and bolt heads that soaks up torque and reduces substantially the pressure available to squeeze the gasket.

Armstrong research engineers have developed a device (shown above) which measures the effect of bolt efficiencies of varying screw thread conditions.

Dry or rough threads, for example, give low bolt efficiencies which develop actual gasket loads much lower than torque readings would indicate. In some cases, as much as 90% of the torque is lost in thread or bolt head friction.

Lubricated threads give high bolt efficiency and result in gasket loads that approach the values calculated from bolt torque.

Data obtained with this Armstrong bolt efficiency test device has led to a method of relating apparent flange pressures (arrived at by calculation) to actual pressures developed in the flange. This procedure compensates for varying conditions of bolt threads.

This data, combined with other new information on seal points of Armstrong resilient gasket materials, substantially reduces the amount of experimental time that is sometimes required to arrive at adequate flange loading. And it will be helpful to designers in meeting the minimum sealing conditions for a particular flange design and gasket material.

Detailed information on this subject and related problems of gasket selection, design and performance are contained in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book. Address Armstrong Cork Company, Industrial Division, 7102 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

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